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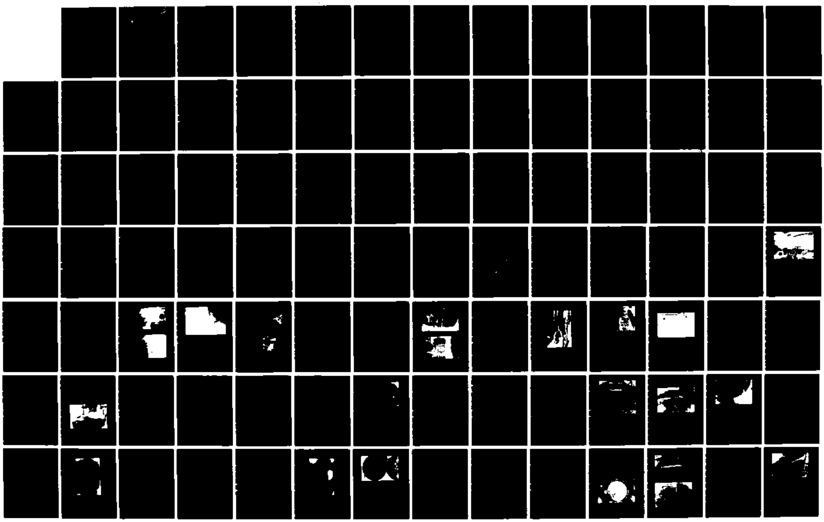

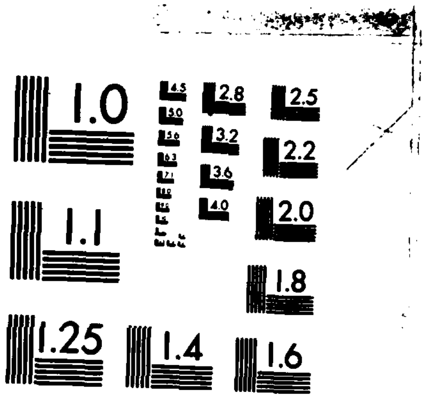
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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
NAVAL FACILITIES ENGINEERING COMMAND

EVALUATIONS OF HRI FACILITIES AT NS MAYPORT AND NAS JACKSONVILLE, FLORIDA—LESSONS LEARNED REPORT

July 1984

An Investigation Conducted by:
SYSTECH CORPORATION
245 North Valley Road
Xenia, OH 45385

N00123-83-D-0149

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METRIC CONVERSION FACTORS

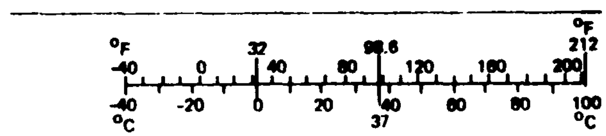
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The heat recovery incinerators (HRI) at ~~NS~~ Mayport and ~~NAS~~ Jacksonville, Fla., were studied to determine any lessons that could be learned from the planning, design, construction, operation, and maintenance of these HRIs. The study examined the various problems in these areas, including description of each problem, an analysis of why the problem occurred, and a

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description of how the problem was alleviated, if it was corrected. Originator-supplied keywords include: Solid waste, and Energy recovery.

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ACKNOWLEDGMENT

This report documents the study and evaluation of the heat recovery incinerator (HRI) facilities at Naval Station (NS) Mayport and Naval Air Station (NAS) Jacksonville, Florida. The report was prepared under the U.S. Navy Contract N00123-83-D-0149 work order ZZ04. The project manager was Mr. Jerry Zimmerle, Naval Civil Engineering Laboratory (NCEL), Port Hueneme, California.

SYSTECH gratefully acknowledges the guidance and support of Mr. Jerry Zimmerle and Mr. Phil Stone both of NCEL and the SYSTECH staff members who assisted in the preparation of this report especially Betty Terrill, Carolyn Lanker, and Dolores Trussell.

SYSTECH wishes to thank the various representatives of the various naval stations, especially Mr. Bob LaVassuer at NAS Jacksonville, Southern Technologies Inc. at NS Mayport, and all the plant operators that devoted time and effort over the several days required on site to complete the evaluation.

SECTION 1.0

EXECUTIVE SUMMARY

The Naval Station (NS) Mayport and Naval Air Station (NAS) Jacksonville, Florida, heat recovery incinerator (HRI) facilities employ two different technological approaches to perform the twofold task of base-generated waste disposal and energy recovery. The NS Mayport HRI utilizes a single 50-ton per day (TPD) field-erected, excess-air, grate incinerator to mass burn the as-received waste. A pit/crane is used to store and retrieve the waste. The NAS Jacksonville HRI utilizes three 24-TPD modular starved-air, refractory hearth incinerators to burn a refuse-derived fuel (RDF) waste. The RDF processing system is located on site, and a live-bottom bin is employed for storage and retrieval of the RDF. The NS Mayport HRI is operational and burns an average of 1.25 tons/hr (TPH) of solid waste 4 to 5 days/wk. The NAS Jacksonville HRI is not operational and has been closed since June 1983.

The objective of this report is to evaluate and compare the performance of these two concepts and to make recommendations concerning future applications within the Navy Shore establishment. In addition, the report defines the lessons learned from the design, construction, and operation of these two facilities. To meet these objectives, the feasibility studies, design documents, and operational data from the two HRI facilities were reviewed. Additional information was obtained from site visits and discussions with facility operators and personnel associated with the various phases of these two projects.

The following are conclusions applicable to both NS Mayport and NAS Jacksonville:

- The duration of the specified performance testing requirements was not sufficient.

- The operational manuals provided with both systems and the on-site training were not sufficient to qualify the operators to fully understand the processes and be able to react to operational upsets.

- The maintenance manuals were not sufficient. Components were not included, wrong components were presented, and parts labeling and preventative maintenance were not detailed.

- The construction drawings were *not* "as built" or kept to date with component changes during construction and shakedown.

- The tested level of particulate air emissions rates would not permit the units to be built in most other states without air pollution control equipment.

- The quality of waste delivered to both HRIs was a major contributor to higher operational cost and lower availability. A large percentage of the waste was nonprocessible (over-sized and/or non-combustible) material which required extensive hand sorting labor and which was the cause of equipment jams and failures.

The following conclusions can be reached specifically for the NS Mayport HRI facility. This HRI facility can be considered a fully operational HRI. It is now accomplishing its mission of waste disposal and energy production. The reliability of the equipment has been acceptable since several equipment modifications were completed and an extensive preventative maintenance program was actively employed. Furthermore, the following major conclusions also can be reached.

- The HRI will require extensive combustion chamber refractory repairs this year. Repairs of this nature will be required every 3 to 4 years.

- The operation is labor intensive due to the extensive requirement for hand sorting the refuse.

- When an aircraft carrier is in port, the facility receives more waste, almost exceeding its capacity.

- Although called "conventional," the HRI design has one-of-a-kind or at best second-generation application of equipment. An identical facility burning similar waste does not exist.

- The system still needs redesign and modification of the following components.

    -- Combustion air supply and controls
    -- Combustion chamber pressure control
    -- Boiler steaming rate measurement
    -- Tipping floor/pit capacity

- The NS Mayport requires additional waste flow control to lower the amount of nonprocessibles arriving at the facility.

- Operation by a private contractor is a good practice for the station. The current contractor is doing a good job.

- The excess-air combustion and mass-burn concept gave the facility an inherent advantage in demonstrating success over the NAS Jacksonville design. The design was simpler, and control of the combustion process by the operator was not as difficult.

The following statements can be made specifically about the NAS Jacksonville HRI facility: The NAS Jacksonville HRI facility is not an operational HRI and never was fully operational. The site was still undergoing equipment modifications when it was closed in June 1983. The following major conclusions also can be reached:

- The building was too small to house the RDF, waste receiving, and incinerator loading tasks.
- The incinerators should not have been placed outdoors.
- Each incinerator should have had its own heavy-duty residue conveyor.
- The boiler did not meet the project specifications and was not properly designed for use in the HRI facility.
- The combustion and steaming rate controls of the incinerator were not designed adequately.
- The maintenance access to the processing and incineration equipment was not designed adequately.
- The flail mill was not isolated or protected from a major explosion that could have injured almost everyone in the plant.
- Dust control covers on the process equipment were not provided, causing excessive fibrous dust to accumulate throughout the facility.
- The screw auger bin is not the proper design to move primary shredded (flail milled) waste.
- Better waste flow control to eliminate items from the waste that repeatedly caused major problems could have improved the plant throughput and improved the reliability of the process equipment.
- The Comtro incinerators had not demonstrated 24-hr operation on municipal solid waste (MSW) prior to their selection, as requested in the project specifications.

The following recommendations for the future procurement of an HRI facility can be made. These recommendations could prevent problems which were encountered at these two sites from occurring at future HRI sites:

- A consulting engineering firm should be contracted to determine waste and steam load amounts and characteristics and to determine the best site for construction. Do not contract with the same engineer to design the HRI facility.
- Request turnkey services from a general contractor/incinerator manufacturer team. Require one or more successful HRI facilities to be listed by the incinerator manufacturer.

- From the qualified listing of three or more applicant teams, request detailed bids. Bids are to include all pertinent specifications of the HRI equipment to be supplied.

- Develop a panel of experts to review the bids and select the lowest of the technically acceptable bids. The panel should be comprised of Department of Defense (DOD) staff experienced with HRIs and consulting engineers under contract. The same panel of experts should review all DOD procurement of HRIs throughout the United States.

- Contract with a consulting engineer to review shop drawings and construction of the HRI.

- After start-up, require 6 to 8 mo of normal operation by the general contractor prior to final acceptance testing.

- Hire a third party for testing the operation over a 120-hr period and for evaluating the facility data gathered over the full 6- to 8-mo operational period before acceptance is granted.

Recommendations concerning specific equipment components are presented in Section 8 of this report.

SECTION 2.0

INTRODUCTION

The objective of this evaluation is to provide a report which details and discusses the lessons learned from the construction, testing, and operation of the HRI plants at NAS Jacksonville and NS Mayport, Florida. The two HRI facilities were constructed by the Navy with the same twofold purpose, i.e., disposal of combustible solid waste and waste oil by incineration along with generation of steam by passing the incinerator flue gases through waste-heat boilers. However, two different approaches were taken by the Navy in the selection of the equipment.

NS Mayport was designed to utilize a single 50-TPD, conventional mass-burn, excess-air grate incinerator system with minimal pre-sorting of the solid waste. A pit/crane was employed for storage and retrieval of the waste. NAS Jacksonville was designed with three, 24-TPD starved-air, refractory-hearth incinerators to burn RDF produced from the NAS waste by a shredder, air scoop, ferrous magnet, and trommel system located on the same site as the HRI. A live-bottom bin and a conveyor system were employed for storage and retrieval of the RDF.

The Navy Civil Engineering Laboratory (NCEL) was tasked by the Naval Facilities Engineering Command to evaluate and compare the performance of these two concepts through review of all available and known literature, design reports, test reports, plans, and specifications and through on-site review of the equipment and discussions with the operators. This report presents a historical perspective of the feasibility studies and preliminary design reports of each facility. For evaluation, each HRI facility is divided into 11 subsections: (1) overall facility, (2) receiving and tipping, (3) processing, (4) storage and retrieval, (5) combustors, (6) dump stack and damper, (7) boiler and auxiliaries, (8) induced draft (ID) fan, (9) atmospheric emissions control, (10) residue and water emissions, and (11) instrumentation and controls.

Life cycle economics are presented based on the available economic data and utilizing a computer program developed for NCEL. Conclusions with respect to performance of major subsystems are presented. Recommendations for future systems based on the evaluation of these two sites are also presented.

SECTION 3.0

HISTORICAL PERSPECTIVE

3.1 HEAT RECOVERY INCINERATION: GENERAL

The first heat recovery incinerator facility was implemented in 1896 in Hamburg, Germany. This facility used refuse to generate electricity and steam for industrial use. Similar facilities soon followed in other European countries as well as in the United States. The first integrated water-tube furnace/boiler was built in Berne, Switzerland, in 1954. This facility, built by Von Roll, consisted of two 100-ton TPD units and generated steam for electricity production. It was operational until 1979. Small excess-air incinerators (with and without heat recovery) have been used extensively in Europe since the early 1960s. These facilities have very successful operational histories, but the capital costs are fairly high by American standards. These facilities are all excess-air, refractory-walled incinerators with a moving grate. A pit/crane design is employed for waste handling, and various pollution control mechanisms, usually either multi-cyclone or electrostatic precipitator (ESP), are used.

Up until the 1960s, incinerators were used in the United States as a method of refuse disposal and volume reduction. These incinerators were uncontrolled-air units. To ensure a high degree of combustion, air was supplied in volumes considerably greater than stoichiometric requirements. Neither the volume of air nor the temperatures were monitored or controlled. These conventional grate incinerators also required large volumes of underfire air to cool the refuse bed and to prevent grate burnout. In turn, the high velocities and large volumes of air required large blowers with high horsepower motors. Consequently, large quantities of both combustible and inert particulates were discharged to the atmosphere with the exiting flue gas.

In 1970, the enactment of the Clean Air Act resulted in the shutdown of many of the old, high excess-air, municipal-waste incinerators. The facility owners were reluctant to add costly air pollution control equipment which would enable them to meet the more stringent air emissions standards. These actions spurred the development of advancements in small modular starved-air incinerators for municipal applications. These systems had already been proven successful in some industrial applications. The first attempts with MSW were not always successful. Problems were experienced with poor burnout and high emissions.

3.2 CONTROLLED-AIR INCINERATORS

The term "controlled air" denotes the control and regulation of air flowing into the combustion chambers. Whereas the air supplied to early generation incinerators was relatively uncontrolled, the velocity and volume of the air supplied to the new units are kept at a calculated minimum to improve the efficiency of the combustion process, to lower the horsepower of the fan motors, and to reduce the amount of particles entrained in the exiting flue gases. The airflow either can be preset to a calculated level based on the amount and type of the waste burned or can be continuously modulated to produce the optimum combustion with the varying system needs and chamber conditions.

Controlled-air incinerators are grouped under two main categories according to the degree of combustion, complete or partial, in the first chamber, also called the primary chamber or furnace. Since complete combustion requires excess air and partial combustion needs substoichiometric conditions, the categories are referred to as excess-air incinerators and substoichiometric or starved-air incinerators. While the airflow in the excess-air incinerators is limited, it still exceeds the stoichiometric requirements for combustion in the first chamber of the furnace. In the substoichiometric incinerators, the air introduced into the primary chamber ranges from 30 to 40 percent of the amount required for stoichiometric combustion, and the air fed to the second or secondary chamber (also called the upper chamber, ignition chamber, afterburner, or thermal reactor) ranges from 100 to 150 percent in excess of the air needed to achieve complete combustion.

3.3 STARVED-AIR INCINERATORS

Some of the controlled-air incinerators are called starved-air incinerators because of the substoichiometric combustion in the primary chamber. The term "pyrolytic" is also applied to the starved-air incinerator, but such a description is not correct. The process of partial oxidation of the waste in the primary chamber is sometimes referred to as pyrolysis. However, true pyrolytic combustion chambers use higher temperatures and a lower amount of substoichiometric combustion air than the starved-air incinerators.

The term "modular" as a descriptor for the starved-air incinerator developed as follows: The starved-air incinerators designed for burning commercial and industrial waste have been constructed of integral components--one for the primary chamber, one for the secondary chamber, and one for each major system constituent. Each component has been assembled and packaged in the factory for immediate on-site installation. Only electrical, fuel, water, and gas duct connections are required at the installation site. When the waste volume has exceeded the capacity of the installed units, additional incinerators are incorporated to meet the increased demand. Since the additional incinerators are constructed and function as modules, the integrated units became known as modular incinerators. Even though the capacity of the modular incinerators has increased from 1 to 4 TPH, most

of the components are still completely assembled and packaged in the factory for immediate on-site installation.

3.3.1 Early Small Industrial/Commercial Units

In the late 1950s, development of the starved-air, small modular incinerator began. These units were designed to have operating ranges of 100 to 700 lb/hr of commercial or industrial waste. These systems consisted of an incinerator with a refractory-lined primary chamber and a vertical afterburner chamber and stack combination. The afterburner was truly an afterburner requiring auxiliary fuel and had a simple on/off switch that was on as long as waste was being combusted. These units were not capable of continuous operation, but rather, were batch fed and required manual ash removal.

3.3.2 Secondary Chamber Implementation

The afterburner/stack was replaced by a secondary chamber, and the capacity of the units was increased to 2500 lb/hr. The control of temperature and airflow in the secondary chamber allowed the burner to be modulated or even shut off after a temperature high enough for self-sustaining combustion of the gases was reached. This minimized the consumption of auxiliary fuel.

3.3.3 Automatic Loading

The earlier units were batch loaded through a door before the unit was ignited. Because of the positive pressure in the chamber caused by the combustion gases and the presence of pyrolysis gases, opening the door while the waste was burning sometimes resulted in flames leaping out the door. Double doors and temperature lockouts were developed to prevent the operator from being injured by such flames. Later, a slight negative pressure was induced in some models to prevent flame escape as the doors were opened.

As the technology developed and the units increased in capacity, the loading system advanced from the door loaders to an enclosed hopper and ram module. This latter equipment allowed more waste to be quickly and safely loaded into the primary chamber. At this point, operation was still cyclical (8 to 10 hr charging time followed by 8 to 10 hr burndown time) to allow the unit to cool down and to manually remove the ash.

3.3.4 MSW Burning Facilities

The first MSW facility to use modular starved-air incinerators was Grafton, Wisconsin, which utilized a Pyro-cone rotary grate furnace in 1968. Following this, facilities were located in Pahokee, Florida, and Orlando, Florida. Both of these facilities utilized Consumat incinerators with automatic loaders, and both began operation in 1974. These facilities operated in a cyclical manner with daily start-up and burndown cycles. Table 1 presents in chronological order some of the HRI facilities that represent technology changes.

4.4 DESIGN MODIFICATIONS DURING CONSTRUCTION

TABLE 1. CHRONOLOGICAL LIST OF STARVED-AIR HRI PROJECTS THAT SUMMARIZES THE CHANGES IN THE TECHNOLOGY

Date	Location	System Size and Vendor	Comments
1968	Grafton, Wisconsin	One 24-TPD, 10 hr/day; Pyro-cone	Rotary grate Fire-tube hot water boiler Cyclic operation Water scrubber for pollution control
1974	Pahokee, Florida	Two 8.5-TPD, 10 hr/day; Consumat	Automatic loaders Cyclic operation No heat recovery
1974	Orlando, Florida	Eight 12.5-TPD, 10 hr/day; Consumat	Automatic loaders Cyclic operation No heat recovery
1975	Siloam Springs, Arkansas	Two 10.5-TPD, 10 hr/day Consumat	Water-tube boilers 120,000 lb/day 100 psig Cyclic operation
1976	Groveton, New Hampshire	One 20-TPD, 24 hr/day; Environmental Control Products	Fire-tube boiler Usually burned wood chips but also burned MSW, 4 to 8 hr, 1 day/week
1977	North Little Rock, Arkansas	Four 25-TPD, 24 hr/day; Consumat	Continuous operation Internal rams Automatic ash removal Water-tube boilers
1977	Crossville, Tennessee	Two 30-TPD, 24 hr/day; Smokatrol	Primary shredder/ conveyor feed Fire-tube boiler Continuous operation never demonstrated
1978	Pelham, New Hampshire	Two 16-TPD, 10 hr/day; COMTRO/Sunbeam	No heat recovery Cyclic operation Continuous burners
1979	NAS Jacksonville, Florida	Three 24-TPD, 24 hr/day; COMTRO/Sunbeam	Water-tube boilers RDF process line Tipping floor/RDF

(continued)

TABLE 1. (Continued)

Date	Location	System Size and Vendor	Comments
1980	Durham/Lamphrey, New Hampshire	Three 36-TPD, 24 hr/day; Consumat	Continuous operation Water-tube boilers Internal rams
1980	Auburn, Maine	Four 50-TPD, 24 hr/day; Consumat	Continuous operations Water-tube boilers Superheated steam (60°F to 100°F) Steel filter baghouse
1984	Tuscaloosa Alabama	Three 100-TPD, Twin 50-TPD, 24 hr/day; Consumat	Continuous operation Water-tube boiler Electrostatic precipitator

3.3.5 Heat Recovery

As the development of modular incinerator technology increased the unit capacity, systems which offered heat recovery capability became available. The incorporation of a heat recovery system with the incinerator necessitated the addition of expanded control systems. However, it wasn't until the energy crisis of the early seventies that the economics of such systems began to appear to be favorable. The first modular systems with heat recovery were employed in industrial applications. Primarily packaged, waste-heat, fire-tube boilers were used. The first municipal modular system with heat recovery that sold the energy to an industrial client was in Siloam Springs, Arkansas, in 1975. This facility consisted of two Consumat 10.5-TPD (10 hr/day) units with waste-heat, water-tube boilers. These units were designed to produce 120,000 lb/day of 100 psig steam. An evaluation of this system in Siloam Springs, Arkansas, and the systems at Pahokee and Orlando, Florida, was conducted in 1976 by Ross Hoffman Associates for the U.S. EPA, Office of Solid Waste Management.[1]

3.3.6 Automatic Residue Removal Continuous Operation

Automatic residue removal was not introduced until 1977. This allowed for continuous operation of larger modular units (over 700 lb/hr). The first facility to incorporate heat recovery with continuous operation on MSW is located in North Little Rock, Arkansas. This facility consists of four 25-TPD (24 hr/day) modular incinerators coupled to two waste-heat, water-tube boilers. Automatic residue removal is accomplished by internal rams in the primary chamber which move the refuse/residue forward until it drops into a water-filled quench tank. The residue is then removed via a drag chain. This

facility was the subject of a detailed economic and environmental evaluation by SYSTECH Corporation in 1979 for the U.S. EPA Office of Solid Waste.[2]

3.3.7 Unit Capacity Increases

Further developments centered around increasing the unit capacity to make modular systems more compatible with the needs of mid-size (100- to 300-TPD) communities. The first 36-TPD modules were constructed in 1979 in Durham/Lamprey, New Hampshire. This facility has three 36-TPD units, providing 108-TPD capacity with heat recovery. The units were manufactured by Consumat, Inc., and began operating in 1980. The facility is still in operation and is supplying steam to the University of New Hampshire.

The next size increase is marked by the Consumat complex in Auburn, Maine. This facility, which has been operational since 1980, consists of four 50-TPD incinerators coupled with two waste-heat boilers. This facility is also the first modular system to produce superheated steam (60°F to 100°F of superheat at 295 psig) and incorporates a baghouse with stainless steel bags to meet emissions standards.

3.3.8 Current State Of The Art

After 1980, changes in modular incinerator technology were developed to cope with the effects of increased unit capacity. The earlier facilities with less than 50-TPD charging capacity were not subject to federal particulate emissions standards. Above that rate though, federal standards do apply. Experience gained from earlier facilities has shown that the starved-air/afterburner (secondary chamber) combination could not consistently meet the federal emission standards. Therefore, the larger facilities have been built with a variety of pollution control equipment such as a baghouse with stainless steel filters, a dry electro scrubber (Pittsfield), and most recently, an electrostatic precipitator (Tuscaloosa).

The increased capacity has also led to the implementation of various new designs for the facility layout and waste handling. While some of the larger facilities still utilize a tipping floor (Auburn, Portsmouth, Durham/Lamprey), others are employing a combination of tipping floor and pit/crane (Pittsfield) to provide additional storage without greatly increasing the area requirements of the facility.

3.4 EXCESS-AIR INCINERATION TECHNOLOGY

The use of excess-air technology for incineration was widespread throughout the world and was especially heavily utilized in Europe. During the 1970s, there were as many as ten different European manufacturers supplying equipment.[3] Their facilities with incinerator capacities in the range of 50 TPD were numerous. Less than 50 percent of these small facilities had energy recovery due to the lack of small energy markets. However, all of these technologies had demonstrated energy recovery capabilities at several sites. Such incinerators were very efficient controlled-air systems, and their reliability was near 100 percent. The European equipment was being sold in the U.S., but sales efforts were active only in the larger scale projects

(at least 250 TPD) wherein the cost per ton of capacity was more cost competitive to alternative U.S. solid waste disposal methods. The small facilities of Europe were relatively unknown to the U.S. market.

Table 2 presents a chronological listing of small excess-air incinerators in the U.S. These facilities were all designed by U.S. consulting engineering firms or vendors. No European designed units were built in the U.S. in this size range. These incineration technologies differed in their approaches to the shape of the combustion chamber, shape and movement of the grates, and methods of residue removal. A pit to store the waste and a crane for retrieval of waste and loading of the incinerator were used. Little information is available on the custom designed 60-TPD unit in Lewisburg, Tennessee, which was built about the same time as NS Mayport. NS Mayport was the smallest operating excess-air municipal waste incinerator until 1982, when the Harrisburg, Virginia, facility was started.

TABLE 2. CHRONOLOGICAL LIST OF EXCESS-AIR HRI PROJECTS IN THE U.S. THAT SUMMARIZES THE APPLICATION OF THE TECHNOLOGY

Date	Location	System Size and Vendor	Comments
1967	Norfolk, Virginia	Two 180-TPD, 24 hr/day; A&E design	Waterwall boiler Oldest operating unit Pit/crane, ESP
1967	Martinsville, Indiana	One 75-TPD, 8 hr/day; Clear Air	Closed in mid 70s No energy recovery Tipping floor Wet scrubber
1971	Waukesha, Wisconsin	Two 175-TPD, 24 hr/day; A&E design Detroit stoker	Water-tube boiler added in 1979 Pit/crane ESP
1976	Portsmouth, Virginia	Two 80-TPD, 24 hr/day; A&E design	Waterwall boiler Pit/crane ESP
1979	Lewisburg, Tennessee	One 60-TPD, 8 hr/day; CICO	Waste-heat boiler Tipping floor Wet scrubber
1979	NS Mayport, Florida	One 50-TPD, 24 hr/day; Washburn and Granger	Fire-tube boiler Tipping floor/pit/crane
1981	Pittsfield, Massachusetts	Three 120-TPD, 24 hr/day; Enercon/Vicon	Continuous operation Water-tube boiler economizer Electo-scrubber Tipping floor/pit/crane
1982	Collegeville, Minnesota	One 65-TPD John Basic	Waterwall primary chamber Reburn tunnel (secondary with excess air) Convection boiler section Tipping floor
1982	Harrisburg, Virginia	Two 50-TPD A&E	Water-tube boiler Pit/crane ESP

SECTION 4

EVOLUTION OF THE TWO NAVY HRI PROJECTS

4.1 OBJECTIVE AND EXPECTATIONS: FUNDING SPONSORSHIP

Funding sponsorship for the NS Mayport HRI was based on environmental considerations. The on-base landfill operation needed to be terminated or continued only for disposal of inert residue. A new U.S. Department of Agriculture regulation required that all garbage from ships returning from overseas had to be incinerated or cooked, ground, and then injected into a sanitary sewer system. In addition, landfill sites off base were expected to soon become so distant from the base that transportation costs would become excessive.

Funding justification for the NAS Jacksonville HRI was based primarily on energy considerations. Interruptible natural gas, the main fuel source for this large industrial and Fleet Air operating base, was soon expected to become unavailable.

Overall, the objectives and expectations delineated for the two new HRI plants, as contracted for construction, were nearly identical. Somewhat simplified, these were:

- Receive about 40 TPD, 5 days/wk, of solid waste generated on base or in adjacent base housing.
- On a continuous, 24 hr/day basis, load and incinerate up to 2 TPH of 5000 Btu/lb solid waste fuel, after some degree of hand sorting or mechanical processing.
- Burn waste oil generated on base simultaneously with solid waste--up to 50 gal/hr at NS Mayport and up to 11 gal/hr at NAS Jacksonville.
- Generate low pressure (less than 250 pounds per square inch guage [psig]) saturated steam for export to an existing base steam distribution system.

4.2 PRELIMINARY FEASIBILITY STUDIES AND SUBMITTALS

4.2.1 NS Mayport HRI

Major feasibility analysis and design for this facility were provided by the architectural and engineering firm of Greenleaf/Telesca and then CERL.

4.2.1.1 First Feasibility Study, 1972--

The Greenleaf/Telesca Engineers of Miami, Florida, performed a report in August 1972.[4] This study estimated generation excluding housing, at 29 TPD on on a 7-day (per week) basis.

4.2.1.2 Second Feasibility Study, 1975--

The U.S. Army Construction Engineering Research Laboratory (CERL) completed a technical report dated March 1975.[5] Major results of this study were:

- NS Mayport generated an average of 25 TPD on a 5-day basis from all sources, including housing.

- The combined waste stream had an average heating value of 6000 Btu/lb.

- The steam production profiles of the two on-base conventional boiler plants were directly related to ... "an ever-changing number of ships being supported by the station and changes in the specific piers used for berthing." Three-year average hourly productions were stated as over 13,300 lb/hr for destroyer piers and 12,900 lb/hr for carrier piers.

- Significant quantities (thousands of gallons per day) of water, contaminated with oil from ships' bilges and fuel tank washings, were being collected. Project P-965 for cleaning the water to disposal standards was well along in the planning and the implementation cycle. On full operations, P-965 was expected to provide over 1 million gallons per year of waste oil product, 95 percent oil and 5 percent water, with NSFO documented as the principal oil component.

- Three HRI technologies were evaluated, based on one shift per operating day:

    -- Rotary basket grate technology (as implemented at Grafton, Wisconsin) was estimated and calculated to be most cost-effective on a life cycle basis.

    -- Rotary kiln combustor technology had intermediate life cycle cost.

    -- Controlled-air HRI technology was least cost effective, based principally on relative estimates of auxiliary fuel requirements.

- Waste fuel processing with a 40-TPH heavy-duty shredder to a 3-in nominal product was recommended for homogenization.

- Principal mode recommended for waste oil utilization was via a burner located in the breeching of the recommended waterwall, water-tube boiler. This burner was in addition to the HRI second

chamber banner which was also recommended for waste oil firing capability.

4.2.1.3 Third Feasibility Study, 1975--

Greenleaf/Telesca completed an updated study in December 1975.[6] Major results of this study were:

- Future projections of solid waste generation more than doubled the previous estimates of 216 tons per week (TPW) to 471 TPW. NS Mayport Public Works office records of 30 TPW average contractor collection from base housing and 240,000 yd^3/yr collections from station and ships are quoted. The projection of over 80 TPD, 5 day/wk was based on:

  -- 165 yd^3/wk @ 500 lb/yd^3 from base housing.

  -- 240,000 yd^3/yr @ 180 lb/yd^3 from ships and station.

- A conservative heating value of 5500 Btu/lb was assumed for the total waste stream.

- NS Mayport sold 319,578 gallons of water-contaminated waste oil at a price of $0.11/gallon in FY 1974. Recent installations of oil/water separators aboard ships were projected to reduce available quantities of waste oil in the future.

- The rotary basket grate HRI at Grafton, Wisconsin, was visited and observed in operation. Based on these observations, this technology was eliminated from consideration. Concerns with combustion temperature control and residue removal were the given reasons.

- Two experimental/prototype HRI technologies, the auger (Hoskinson) combustor and a slag forming furnace, were included in the evaluations. The auger (Hoskinson) combustor was rated next to the lowest on economics and lowest on the remaining evaluation factors. The slagging furnace was rated virtually equal to the highest on economics and intermediate on other factors. The lack of operating experience and the untried nature of the slagging portion of the combustor eliminated it from consideration.

- Starved-air combustor technology was rated lowest in life cycle economics and intermediate on other factors. The very low rating in the life cycle economic evaluation was based on an estimated requirement for eight 1-TPH units (each operating 12 hr/day), high consumption of auxiliary fuel, and poor thermal efficiency.

- The recommended combustor technology was a conventional, refractory-wall, stoker-grate system. Two 2-TPH units would be needed for the estimated waste loading.

- Waste fuel processing to minus 12 in. with an 800-hp horizontal rotor hammermill was recommended for more efficient and complete burnout, more uniform combustion, and better heat recovery.

- It was stated, "Items less than 12 inches equivalent diameter by 4 feet in length can be routinely processed in the recommended incinerator;" that is, with some sorting, operation of the conventional HRI on "raw" waste was acceptable.

- Water-tube boilers (as also recommended by the CERL report) were recommended. It was stated that since off-the-shelf package boilers compatible with the selected incinerator were not available, a custom balanced double "D" type boiler with an economizer was recommended.

- Steam-to-air heat exchangers, roof mounted, were recommended for continuing waste incineration when lacking sufficient steam demand.

Estimated staffing/manning for the 80-TPD HRI plant was:

Each of 3 shifts:	1 RDF operator 1 furnace/boiler operator 1 maintenance person
PLUS, day shift only:	1 front-end loader operator 1 general cleanup person 1 additional maintenance person
For starved-air HRIs:	add to the above for each of three shifts/day 2 ash removal/cleanup men

4.2.2 NAS Jacksonville HRI

4.2.2.1 First Feasibility Study, 1975--

The Naval Facility Engineering Command (Southern Division) originated the NAS Jacksonville HRI facility concept in 1975 in conjunction with a coal-fired boiler or alternative energy sources as a fuel replacement to the interruptible natural gas supply at the station. Several concepts, including mass burn and RDF co-firing with coal, were considered for the solid-waste/heat recovery project.

4.2.2.2 Second Feasibility Study, 1976--

Additional concept designs and cost estimates were prepared by the A&E firm of Reynolds, Smith, and Hills, Jacksonville, Florida, in April of 1976.[7] Major results of this study were:

- The concept design showed the facility on the site at which it was eventually built. However, the waste processing system was shown as being located outside of the building versus the final design wherein the waste processing system was located within the building, and the building spanned the drainage ditch located on the site.

- The building, 80 ft × 80 ft in dimension, housed the tipping floor and the waste feed/return conveyor. The incinerators were shown outside the building much like the layout at the Blyville, Arkansas, HRI facility.

- The RDF process line included a shredder, air classifier, and ferrous magnet.

4.2.2.3 Third Feasibility Study, 1977--

Reynolds, Smith, and Hills submitted preliminary design calculations which served as a basis for design and outline specifications for the HRI facility.[8]

Major items are:

- The process line will be designed to handle 5 TPH. Two shifts will be required on Monday.

- The process equipment included a flail mill, industrial shredder, air scoop and cyclone, magnetic separator, trommel screen, storage bin, and incinerator feed conveyor.

- Each of the incinerators can burn 20 TPD of unprocessed and 14.5 TPD of processed material.

- A water-tube boiler capable of 5000 lb/hr of 125-psig steam will be utilized. Overall efficiency is expected to be 60 percent.

- Designed for maximum waste delivery of 70 tons on Monday of each week, average daily capacity of 40 tons for 5 days.

- Designed for processing of 40 tons in 8 hr thus requiring 30 tons storage on the floor. Determined that 1500 ft^2 is required to store 30 tons at 4 ft high and a density of 10 lb/ft^3.

- Stated that due to space limitation behind Power Plant 2, larger tipping floor is not possible.

- Estimated that for every 40 ton processed, approximately 29 ton or 72 percent will reach the storage bin. Average bulk density of the material is 6 lb/ft^3. Stated that within the bin the material compacts 15 percent so that the density in the bin is 7 lb/ft^3.

- Volume of the bin should be 34 × 20 × 15 ft to store 23 tons at a depth of 10 ft and at a density of 7 lb/ft^3.

4.2.2.4 Fourth Feasibility Study, 1977--

Reynolds, Smith, and Hills prepared a report for the 100 percent design submitted in May 1977, presenting the final layout of the HRI facility.[9] Major results of this study were:

- The project was limited by the available authorized funding in the sum of approximately $2,000,000. Therefore the cost of the project was presented as a base bid plus additive alternatives. The base bid only included the two 20-TPD incinerators and the RDF process line all within one building. The first additive was an industrial shear shredder and conveyor system to handle the large wood and cardboard items. The second additive was the third incinerator. The third additive was the truck scale.

- The design of the facility and the specifications were based on the following equipment items and manufacturers:

Item	Manufacturer	Model Number
Trommel	Gruendler	Type 48 ft × 9 ft
Flail mill	Gruendler	Model 30 × 48
Cyclone	Southern Engineering	Type 6 ft diameter
Storage bin	Miller Hofft	Type H
Incinerator	Consumat	C-1200
Boiler	Riley-Beard	Model CAS-805
Shredder	Gruendler	Model 54 × 34

- The building was described as 11,160 sq ft. The project cost estimate for the base bid was $1,887,700, and a total of $2,482,700 was projected with all the additive bids.

4.2.2.5 Design Review, 1977--

Several meetings were held during March to June 1977 between Southern Division; other Naval personnel; and Reynolds, Smith, and Hills concerning the facility equipment specifications. Important items discussed and actions taken were:

- Raised the capacity of the incinerators from 20 TPD to 24 TPD.

- Confirmed the reliability of a single drag chain to service all three incinerators based on performance at the Kingsland, Texas, HRI facility.

- Changed the boilers in the base bid from water tube to fire tube and then made the water-tube boilers an additive bid.

4.2.2.6 Operation Analysis--

An estimate of the HRI operating cost was prepared by NAVFAC Southern Division in March 1978.[10] Major items of this study were:

- Based on the data provided by Reynolds, Smith, and Hills, an estimated $236,000 would be required for operations and maintenance the first year.

- The labor force would total 11 for the 120-hr mission, and no major maintenance or equipment replacement would be required in the first 5 to 10 years.

- Based on an annual steam production of 93,600 MBtu, fuel savings would be about $340,000 if off-setting No. 6 oil and $180,000 if off-setting natural gas.

- Additional savings in solid-waste hauling and disposal would amount to approximately $58,000/yr.

- The HRI facility was projected to produce approximately $138,000/yr in overall savings.

- Operation by Naval personnel versus private contractor was evaluated. An estimate of $318,000/yr for operation was obtained from an unnamed private contractor experienced in operating such a system. The Navy decided to operate the plant themselves and gave the following reason "... to be operated by Navy personnel because of administrative and contract liabilities inherent to start-up of the plant and integration of the plant into the existing NAS Jacksonville logistic support function." However, during this period of project development, the Navy did not allocate any additional billets (positions) for operation of the HRI. Ultimately, boiler operators and maintenance staff had to be diverted from other tasks to operate and maintain the HRI.

4.3 DESIGN AND GENERATION OF BID DOCUMENTS

4.3.1 Prior Experience and Scope of Contracts of A&E Firm

4.3.1.1 NS Mayport--

The Mayport facility was designed by Greenleaf/Telesca with the aid of a consultant, Mr. B. B. Reilly.[11] No copy of their contract scope of work was located. Greenleaf/Telesca listed two previous inclined-grate incinerators: Ft. Lauderdale (225 TPD) and Northwest Dade County, Florida (300 TPD), as being designed by their firm. Mr. Reilly listed experience with a 54-TPD incinerator for Eastman Kodak in Rochester, New York. He also custom designed the feed hopper and torque-tube refuse feed system for the Kodak HRI.

4.3.1.2 NAS Jacksonville--

The HRI facility was designed by Reynolds, Smith, and Hills.[12] No previous experience in the design of incinerator systems is listed in the available documentation. It appears that the firm was hired to consider the

application of a coal-fired boiler system in lieu of the natural gas units and became involved with solid waste as an alternative fuel when co-firing of RDF and coal was initially considered. Their subsequent selection to design the HRI was apparently an extension of their previous contract for the coal-burning facility. The scope of work in the contract stated that the facility be designed to include three 20-TPD capacity package incinerators, auto loaders, conveyor system, shredder, magnetic ferrous recovery, vibrating screen, tipping floor, storage pits, and water-tube boilers for heat recovery. The facility was to receive waste from NAS Jacksonville and Cecil Field.

4.3.2 Systems Integration With Base Requirements

4.3.2.1 NS Mayport--

The 1975 feasibility study was the only available design document.[6] A 100 percent design document was not located. The document listed the Naval Station's requirements for disposal of 94 TPD 5 day/wk of solid waste and 320,000 gal/yr of waste oils and energy recovery in the form of 200 psig saturated steam, 24 hr/day.

4.3.2.2 NAS Jacksonville--

The Naval Air Station required a system that could dispose of 70 TPD of solid waste, 57 TPD of their own waste and 13 TPD from Cecil Field. The energy recovery was to be in the form of 125 psig saturated steam. The system was also to be capable of burning 130,000 gal/yr of waste oils.[9]

4.3.3 Siting

4.3.3.1 NS Mayport--

The original site for the facility was discussed in the 1975 CERL[5] and the 1975 Greenleaf/Telesca feasibility studies.[6] The site was on the north side of Massey Avenue near Main Street and across from an existing steam plant. This site presented potential traffic problems. In addition it would be necessary for the steam line to be laid under the street. The site was approximately 300 x 400 ft in size. The final site selected for the HRI facility was an equal size lot across the street on the north side of Massey Avenue. No written explanation for the change was located in the available documentation. The new site did shorten the length of the new steam line and eliminated the need to lay the steam line under the street.

4.3.3.2 NAS Jacksonville--

The original and final sites were at the same location.[7,9] However, the amount of space finally allocated to the HRI facility was less than half that used in the preliminary concept designs. The site is adjacent to Power House No. 2. The available area was restricted due to a large group of trees, an electrical switch yard, and a drainage ditch. The original concept showed the plant astride the drainage ditch. It is assumed that monetary constraints for the project construction did not permit the development in the above manner.

4.4 DESIGN MODIFICATIONS DURING CONSTRUCTION

4.4.1 NS Mayport

There were ten reported modifications to the facility during construction.[13] Data on the details of all ten are not available. The total cost of the modifications were approximately $570,000. The following details were available.

- Installed a door allowing passage from the control room out onto the feed hopper platform. No cost was available.
- Increased the capacity of the water softener from 11 hr to 24 hr between recycling when operating at 25 gal/min. Cost was approximately $5,000.
- Made repairs during construction to the ram in July 1979 for a cost of approximately $9,500. No details were available.
- Made repairs during construction to the ram feeder base in March 1979. No details or cost were available.
- Made repairs during construction to the drag chain and cleaned the quench tank in August 1979 at a cost of approximately $4,600.
- Made revisions in the control wiring circuit in August 1978 for a cost of $15,000. No details were available.
- Upgraded the crane electric circuit from 60 amps to 100 amps for a cost of $2,000.

4.4.2 NAS Jacksonville

A total of 15 modifications were reported during the construction.[13] One modification for about $55,000 was made at the request of NCEL. Two fans on the back wall of the building were moved, and a doorway was moved to permit a future building addition. No changes in the design concept were involved. The remaining 14 modifications totaled about $443,000. Only a few details were available. Most of the modifications were small in dollar amounts, usually ranging between $5,000 and $9,000. The following are major modifications that were identified.

- A Fenwal explosion prevention system was added to the flail mill and cyclone at a cost of approximately $75,000.
- The boiler in incinerator Unit Number 3 was changed from a fire tube to a water tube at a cost of about $37,000.

- In March 1979 a large modification totaling $280,000 was approved No details were available. However, it is thought that this sum was an adjustment for inflation and overhead on work already completed.

- The incineration system controls were located on the tipping floor rather than in the control room. The control room became an office.

SECTION 5.0

DETAILED DESCRIPTION OF NS MAYPORT - NAS JACKSONVILLE FACILITY HARDWARE AND PERFORMANCE

5.1 OVERALL FACILITY - NS MAYPORT AND NAS JACKSONVILLE

5.1.1 Size and Functional Area Allocation - NS Mayport

The NS Mayport, Florida, HRI is located next to the destroyer pier fossil fuel power plant. The sight layout is shown in Figure 1 and the building layout is shown in Figure 2.[14] The process flow diagram is shown in Figure 3. The 50-TPD incinerator system and associated subsystems are housed in a 140 × 180-ft, flat-roofed building with an eave height of 38 ft.[15] The building is situated on a 240- × 330-ft site. The main floor is divided into the following areas:

- The refuse receiving and storage area which consists of a 60- × 100-ft tipping floor.
- A 60- × 20- × 11-ft-deep storage pit with a 20-ft-high wall on three sides provided for refuse storage/stacking.
- The incinerator subsystem, consisting of the feeder, incinerator, and dump stack, occupies an area measuring 28 × 78 ft.
- The boiler area measures 12 × 52 ft.
- The air pollution control equipment, including the ID fan and multiple cyclone dust collector, occupies an area of 22 × 40 ft.
- The feedwater subsystem, consisting of a lab sink, deaerating tank, water softener, and blowdown tank, occupies a 16- × 52-ft area in the northeast corner of the building.
- A 30- × 24-ft utility room, which houses the auxiliary generator, is also provided.
- Space has been allocated for a second incinerator/boiler unit. A 57- × 64-ft area is provided for the incinerator and a 30- × 52-ft area for the boiler.

The control room is located on the west side of the building overlooking the incinerator. The room, which is 17 × 18 ft, provides a view of the

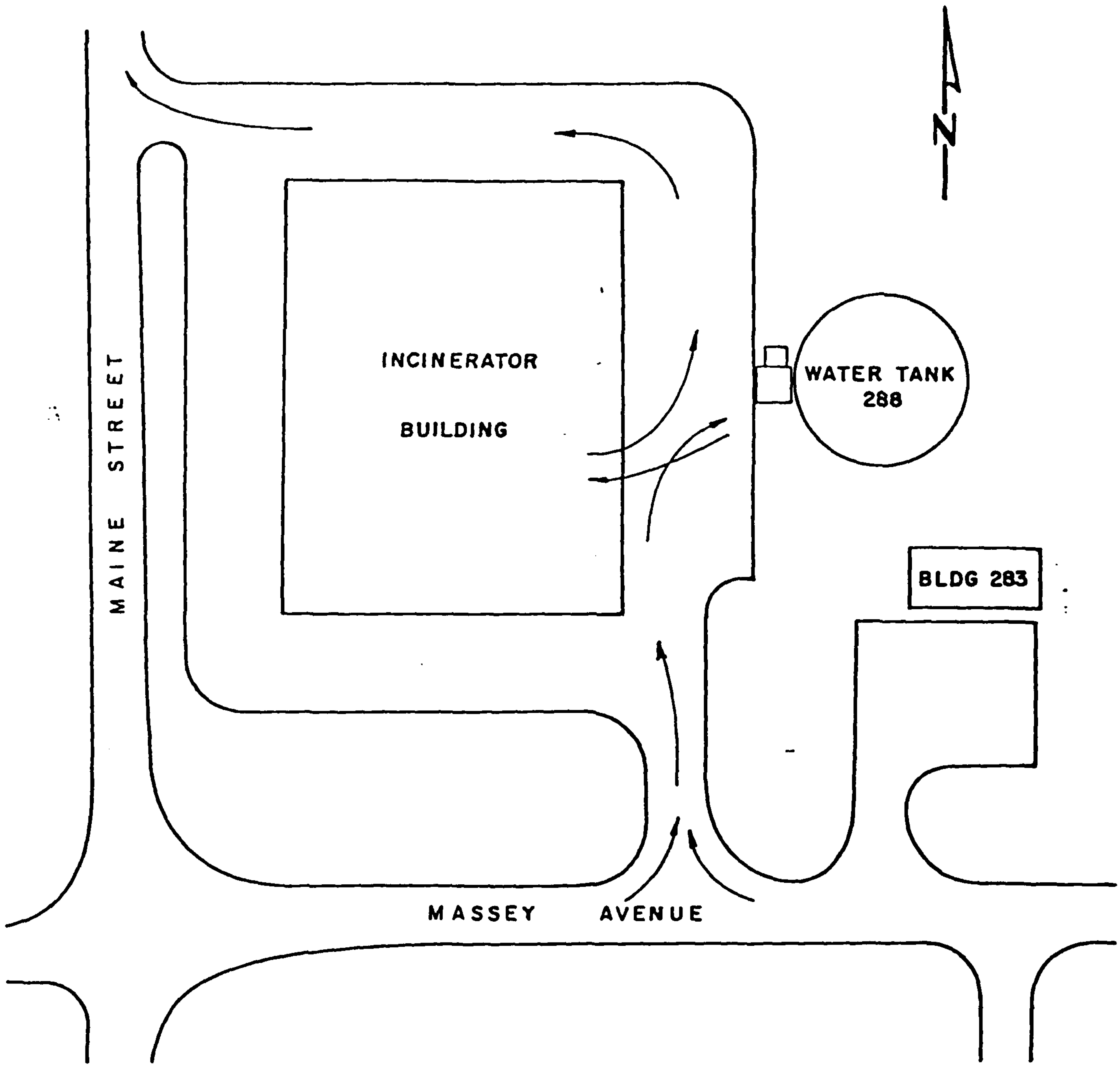

Figure 1. NS Mayport HRI site plan.[11]

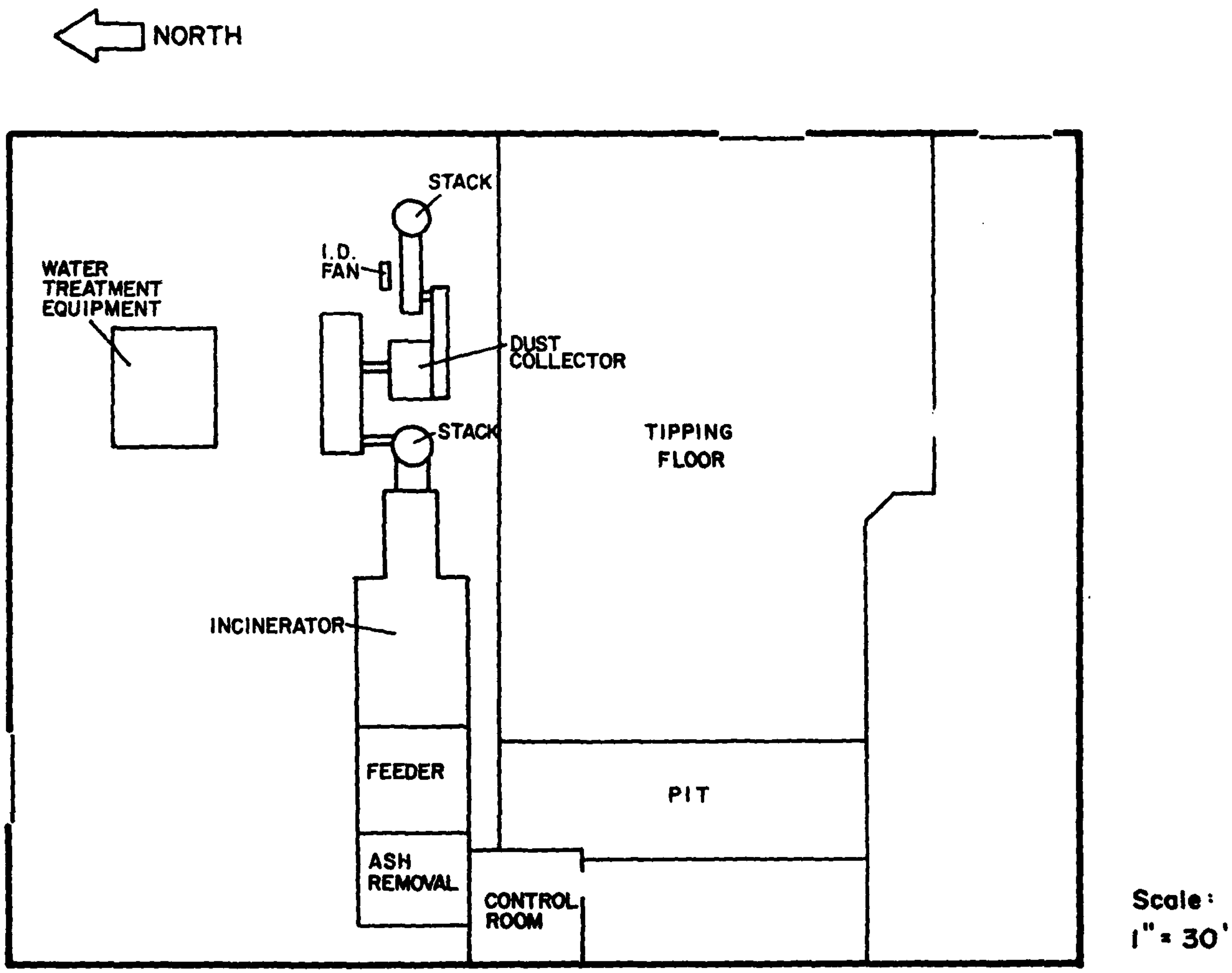

Figure 2. Layout of NS Mayport HRI facility.

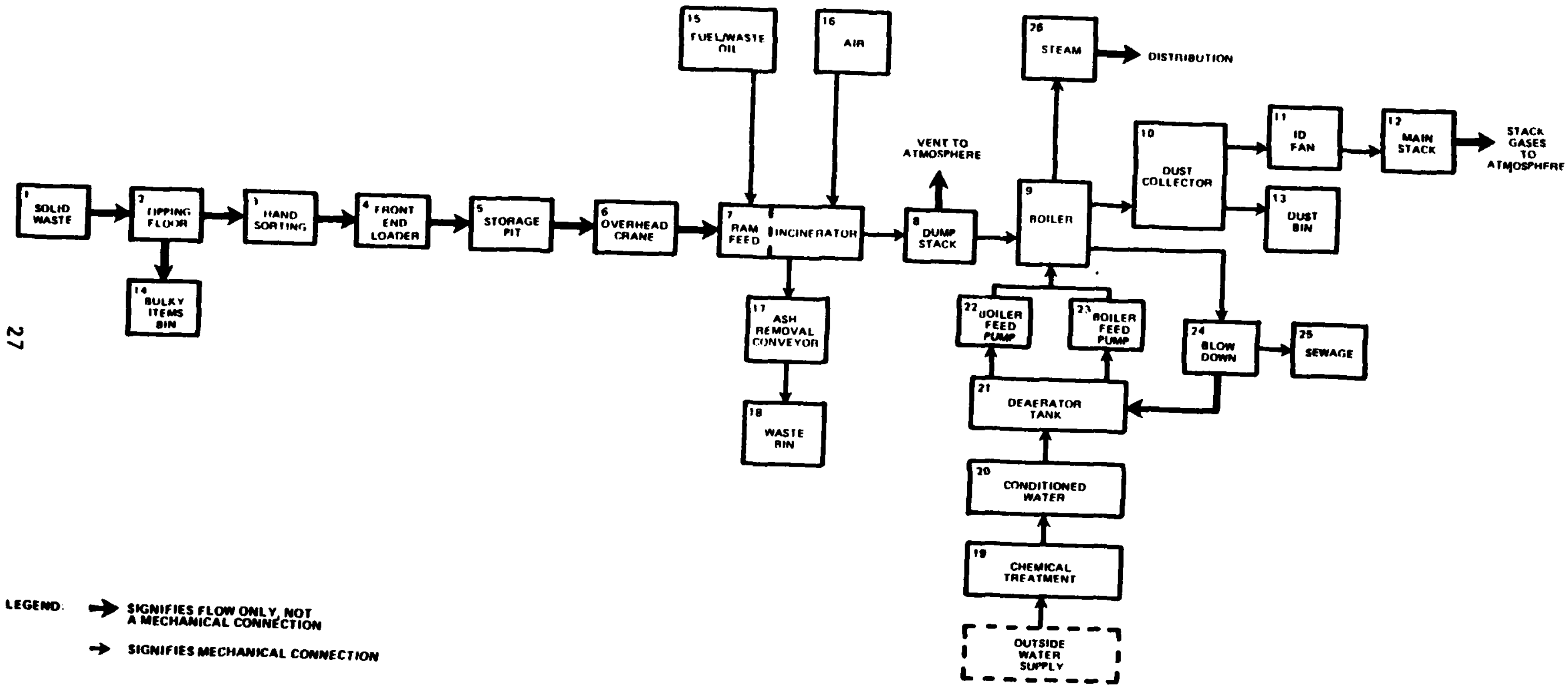

Figure 3. HRI functional flow diagram, NS Mayport.[16]

incinerator, boiler, and tipping floor. The control room is the third level of rooms above the utility area. The second level houses the restroom/locker area and two offices for plant personnel.

5.1.2 Waste Stream Characteristics - NS Mayport

Two types of waste streams, refuse and waste oil, are disposed at this facility. The following paragraphs outline the individual characteristics of these waste streams.

5.1.2.1 Solid Waste Stream Characteristics--

On the average, the facility receives 35 TPD of refuse, 5 day/wk. Peaks of 50 TPD occur when a carrier is in port. When there are no carriers in port, the receiving rate is as low as 25 TPD. Housing waste accounts for 4 TPD with the remainder of the waste coming from mission activities and support operations. Approximately 3 TPW of metal and 2 TPW of bulky waste are removed from the refuse. Tables 3, 4, 5, and 6 show the composition of the solid waste.

5.1.2.2 Waste Oil Characteristics--

The waste oil is off-loaded from the ships in port and can be contaminated with water and sludges. The oil is obtained from the oily water cleanup system at the station. About 6000 gal/mo of waste oil is burned. Table 7 presents the characteristics of this waste oil. The oil is stored on the HRI site in two underground tanks, each with 6000-gal capacity. Waste oil is burned in the secondary combustion chamber at an average rate of 50 gal/hr and a maximum of 80 gal/hr.

5.1.3 Size and Functional Area Allocation - NAS Jacksonville

The NAS Jacksonville, Florida, RDF/HRI system is located adjacent to Power Plant No. 2. The site plan is shown in Figure 4. The RDF processing system and incinerators are situated on a 210- × 390-ft site. The pre-engineered metal building, which houses the tipping floor and RDF processing and storage equipment, measures 120 × 90 ft and has a gable roof with a 1 in 12 slope and a sidewall height of 24 ft. The building layout is shown in Figure 5, and the process flow diagram is shown in Figure 6. The main floor is divided into the following areas:

- The refuse receiving and storage area consists of a 42- × 75-ft tipping floor. Two 4-ft-high push walls are provided to separate the tipping floor from the flail mill and the industrial shredder.

- The RDF processing equipment occupies two areas, a 20- × 120-ft area for the flail mill, magnetic separator, air scoop and trommel and a 33- × 68-ft area for a surge bin and associated conveyors.

- The incinerator feeder/hopper area occupies approximately 20 × 50 ft. Contained within that area are the incinerator control panels. Each of the three panels occupies an area of approximately 4 × 6 ft within the feeder/hopper area.

TABLE 3. NS MAYPORT WASTE COMPOSITION RESULTS - WEEKLY AVERAGE, NOVEMBER, DECEMBER 1980* (Average of Daily Results, As-Received Basis)

Category	November Weight (%)	November H_2O (%)	December Weight (%)	December H_2O† (%)
Cardboard	15.6	22.0	15.2	--
Other paper	24.7	28.9	29.5	--
Food waste	4.2	69.0	5.8	--
Yard waste	4.3	34.2	5.9	--
Wood	5.0	18.9	3.1	--
Ferrous	4.9	8.5	5.3	--
Aluminum	1.8	14.6	1.0	--
Other metals	0.6	0.6	1.4	--
Glass	4.0	1.4	4.4	--
Plastics	8.3	6.9	10.4	--
Textiles	6.4	14.2	6.6	--
Inerts	2.3	16.8	1.5	--
Fines	18.1	40.9	9.9	--

*Reference 14
†Not tested

TABLE 4. NS MAYPORT WASTE HEATING VALUE AND MOISTURE CONTENT, DECEMBER 1980*

Basis	HHV (Btu/lb)	LHV (Btu/lb)	Moisture (%)
As-received	5134	4502	25.1
Dry weight	6854	6011	--

*Reference 14

TABLE 5. NS MAYPORT REFUSE HIGHER HEATING VALUES, DECEMBER 1980* (Dry Weight Basis)

Category	Standard HHV† (Btu/lb)	Measured HHV (Btu/lb)
Cardboard	7,791	7,862
Other paper	7,429	7,420
Food waste	8,162	9,042
Yard waste	7,282	8,006
Wood	8,253	8,423
Plastics	13,630	15,827
Textiles	8,793	8,452
Fines	3,457	4,568

*Reference 14

†Kaiser, Elmer R., P.E., "Physical-Chemical Character of Municipal Refuse," Combustion Magazine, February 1977, pp. 26-28.

TABLE 6. NS MAYPORT REFUSE, ULTIMATE ANALYSIS, WEEKLY AVERAGE, DECEMBER 1980* (Dry Weight Basis)

Carbon	38.69
Hydrogen	5.12
Oxygen	27.17
Nitrogen	0.81
Chlorine	0.75
Sulfur	0.22
Inerts	27.18

*Reference 14

TABLE 7. NS MAYPORT WASTE OIL PROPERTIES, DECEMBER 1980*

	November		December	
	Tank 1	Tank 2	Tank 1	Tank 2
HHV (Btu/lb)	19,704	19,782	19,425	19,753
LHV (Btu/lb)	18,559	18,637	18,280	18,608
Density (lb/gal)	6.890	6.890	6.826	6,841
Moisture (%)	--	--	<0.2	<0.2

Ultimate analysis (estimated) (%)	
Carbon	86
Hydrogen	12
Oxygen	--
Nitrogen	--
Chlorine	--
Sulfur	0.5
Inerts	--

*Reference 14

- The maintenance area, locker room, and office are on two levels. On the first level are the men's and women's locker rooms (20- × 18-ft total area) and the maintenance area (20 × 15 ft). On the second level is the office (20 × 15 ft) and a parts storage area (14 × 18 ft). The deaerator tank sits above the office on a third level, accessible by means of a small ladder.

The incinerator and boiler equipment are located outside the building. The following area allocations apply:

- The three incinerators occupy a total area of 38 × 50 ft.

- The three boilers and the ID fan are also outside, mounted above the incinerator on a platform. They occupy an area of approximately 38 × 50 ft.

- The single residue removal system is located in a 10- × 83-ft area behind the three incinerators.

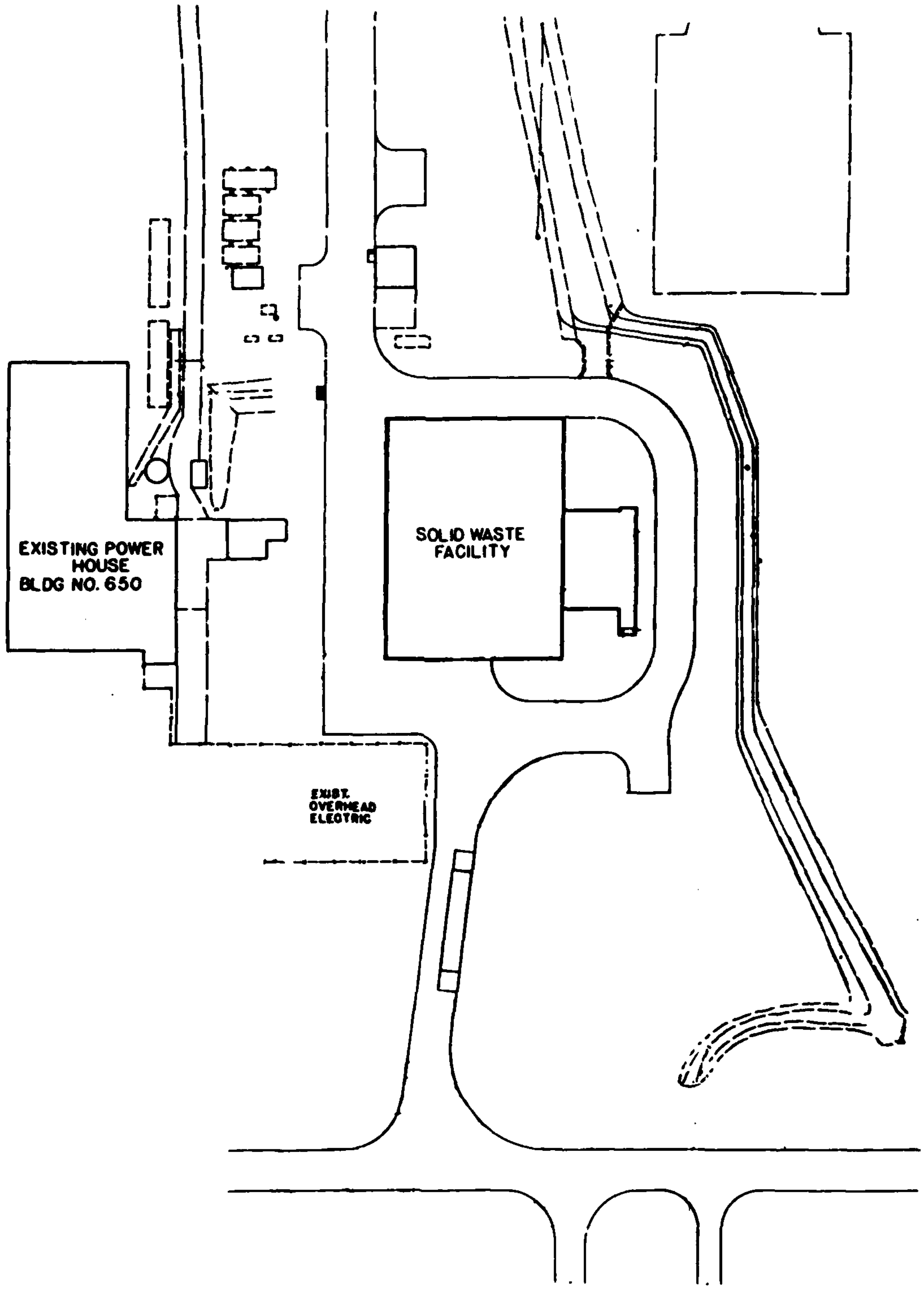

Figure 4. Site layout, NAS Jacksonville HRI facility.[17]

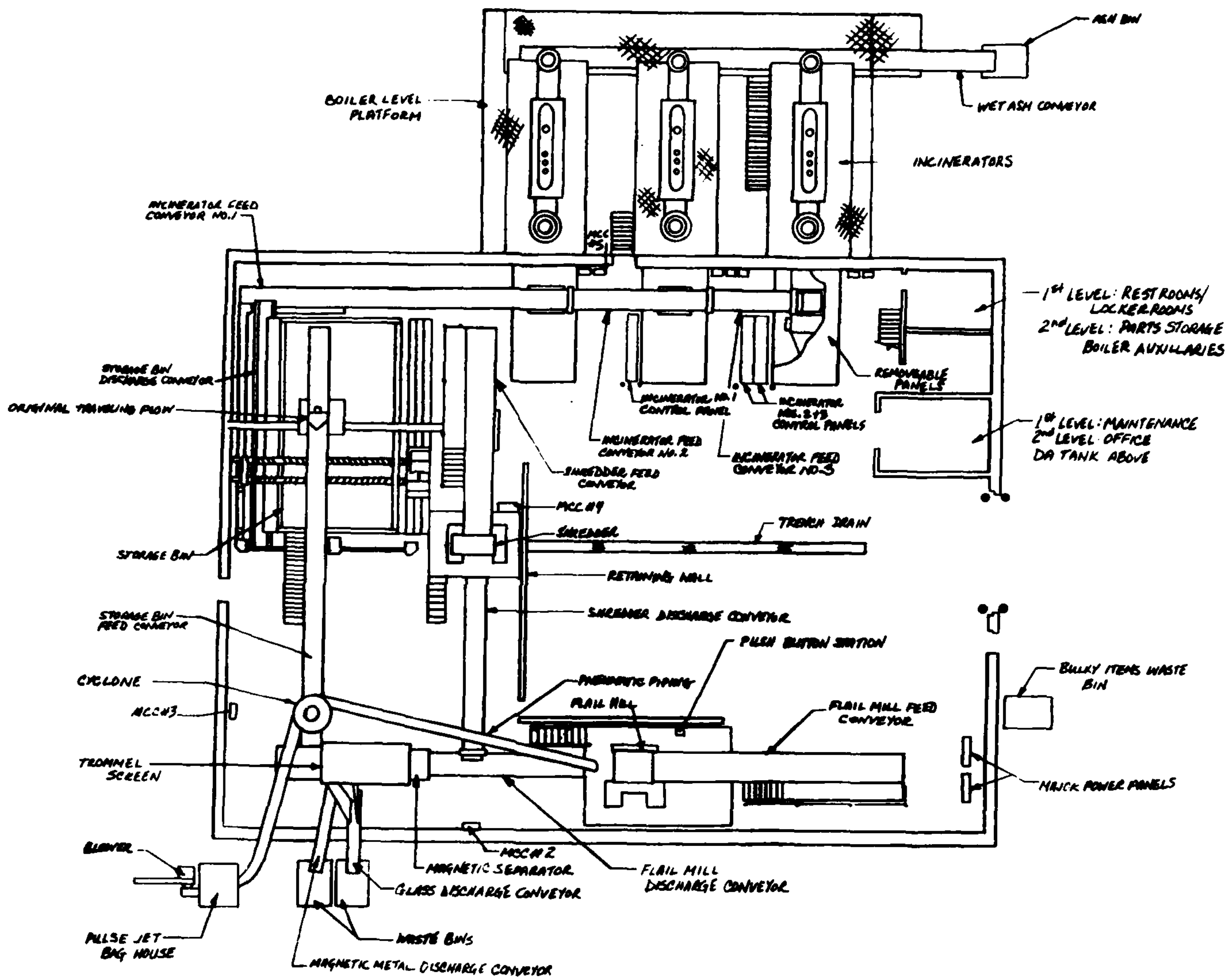

Figure 5. Layout of equipment at HRI, NAS Jacksonville.[17]

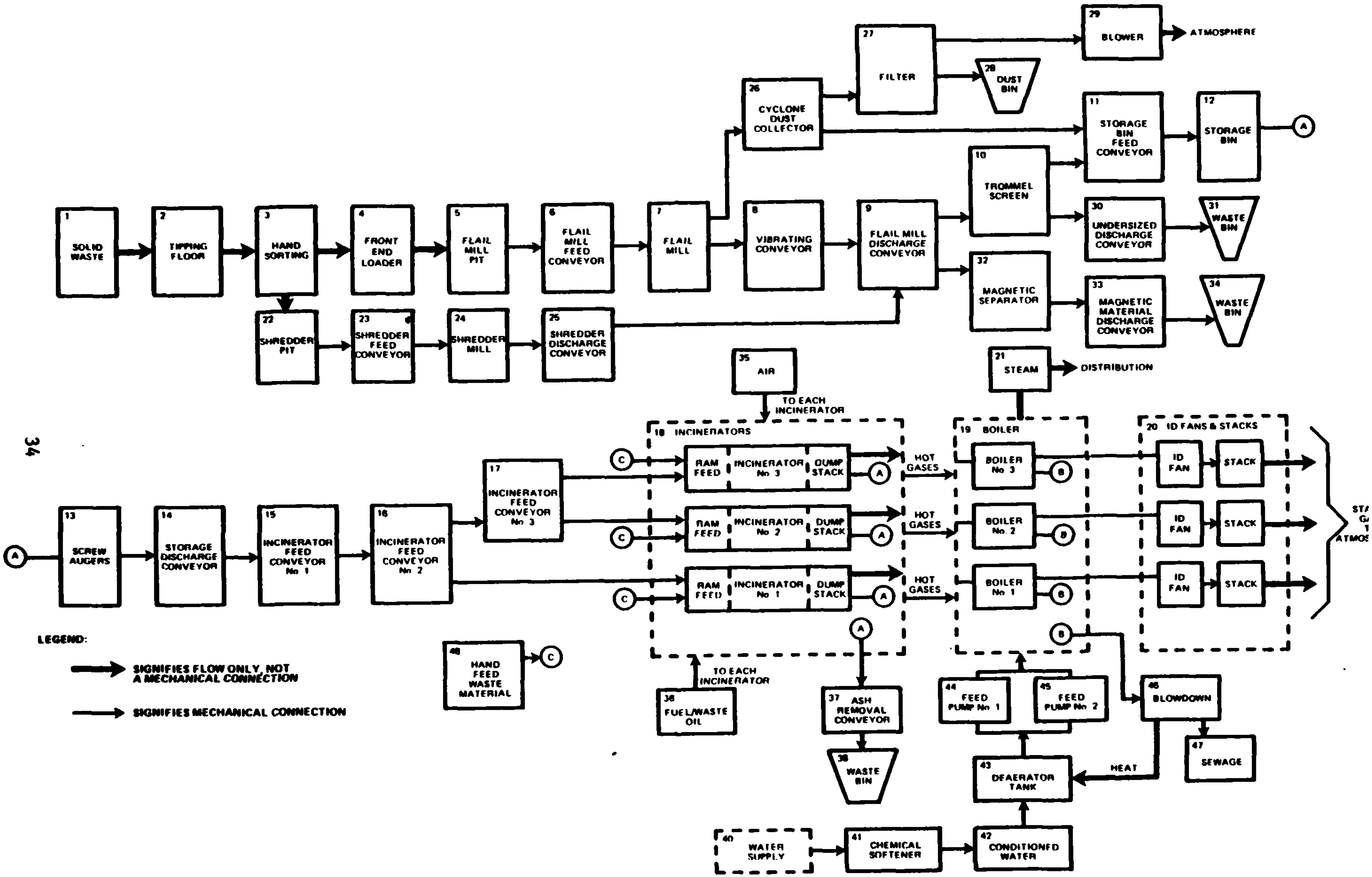

Figure 6. HRI functional flow diagram, NAS Jacksonville.[13]

- A free standing 10- × 20-ft scale office is located alongside the approach driveway.

- The boiler makeup water supply is located in the adjacent Power Plant No. 2.

5.1.4 Waste Stream Characteristics - NAS Jacksonville

The solid waste generated at NAS Jacksonville is predominatly (approximately 68 percent) industrial/oversized type wastes. Tables 8 and 9 present the results of a solid-waste characterization done at NAS Jacksonville in September of 1980. The incoming solid-waste characteristics reported in that study did not represent the entire base-waste generation. Some refuse was directed to the landfill site during the test period, and as a result, the reported characteristics represent half of the waste generated and are weighted heavily with industrial, commercial, and food service wastes. Paper, cardboard, and wood accounted for 83 percent of the incoming refuse. The glass content averaged 10 percent, which is relatively high compared to municipal refuse. The average Btu content was 8300 Btu/lb on a dry basis. During the 4-day test period, 53 tons of refuse were delivered to the HRI, while base generation averaged 28 TPD. Figure 7 shows the typical composition of the waste received at the HRI. The waste delivered to the facility was frequently contained in 20- to 40-yd^3 roll-off units. These units typically receive the industrial large bulky items but not the household waste. The roll-off units cost more to transport to the landfill site than packer trucks so dumping them at the HRI saved the station more on disposal fees.

5.2 RECEIVING AND TIPPING - NS MAYPORT AND NAS JACKSONVILLE

5.2.1 Platform Scale - NS Mayport

A 35-ton truck scale is available for recording weights of incoming refuse and outgoing nonprocessibles. The scale is not visible from the control room. The readout is located in the control room. The signal horn is used to signal the plant personnel when a truck is on the scale. The truck scale is generally not used during routine operations. Instead, the scale is used periodically to determine the waste generation associated with a particular activity. The scale does not have sufficient capacity to weigh the full ash container, estimated to be 74,000 lb. This must be weighed at another scale in the station.

5.2.2 Tipping Floor - NS Mayport

5.2.2.1 General Description--

The 60- × 100-ft tipping floor provides storage for 50 to 60 tons of refuse against the walls. No floor drains were provided. The actual floor storage (tons) varies, depending upon the type of waste received. The cardboard and bulky wood wastes require more storage space per ton than the household waste. Refuse is sometimes received 7 days/wk as described in Section 5.1.2. Floor storage limitations are encountered when a carrier is in port or when general base waste is delivered on Saturdays and Sundays.

TABLE 8. NAS JACKSONVILLE INCOMING SOLID WASTE CHARACTERISTICS, SEPTEMBER 1980*

Day	Percent by Weight										
	Paper	Cardboard	Plastic	Food waste	Wood	Grass	Textile	Ferrous	Aluminum	Glass	Dust
Monday	27	17	4	4	33	0	0.2	3	1.7	10	0.1
Tuesday	38	18	10	12	1	2	4	3	0.5	11	0.5
Wednesday	40.2	13.3	10.2	1.8	0	0	6.9	9.7	2.9	14.5	0.5
Thursday	18	20	20	34	1	0	1	2	1	2	1
Weighted weekly average	34	17	9	9	12	1	3	4 4	1 1	10 10	T T

*Reference 18

TABLE 9. NAS JACKSONVILLE PROXIMATE AND ULTIMATE ANALYSES, INCINERATOR FEEDSTOCK, STEPTEMBER 1980*

Test	Btu/lb (dry)	Proximate Analysis (as received)				Proximate Analysis (dry)			Ultimate Analysis (dry)				
		Volatile matter	Ash	Fixed carbon	Moisture	Volatile matter	Ash	Fixed carbon	C	H	N	S	O_2†
1	8487	81.60	8.48	2.88	7.04	87.78	9.12	3.10	47.77	5.80	0.22	0.23	36.86
2	8081	57.11	7.32	13.95	21.62	72.86	9.34	17.80	47.93	5.97	0.28	0.20	36.28
3	8055	NR§	NR§	NR§	NR§	NR§	NR§	N	NR§	NR§	NR§	NR§	NR§
Composite sample	8207	69.36	7.90	8.42	15.41	80.32	9.23	10.32	47.85	9.23	0.25	0.22	36.57

*Reference 18
†By difference
§NR = not reported by laboratory

Figure 7. View of as-received waste at NAS Jacksonville prior to hand sorting to remove large bulky items and nonprocessibles.

5.2.2.2 Operation and Maintenance--

A front loader is used to first stack waste in the corner, then to spread the refuse on the tipping floor for hand sorting, and finally to push the sorted refuse into the storage pit. The current front loader with a 1.5-yd^3 bucket is slightly undersized, whereas a previous 3-yd^3 loader was too large to maneuver in the available space and to spread the refuse evenly for hand sorting activities. Tire wear on these loaders is high due to the abrasive nature of the refuse, the number of forward/back cycles, and the spinning of the tires during the stacking of the refuse.

There is no power ventilation over the tipping floor area, so that dust and odors from dumping the waste are a problem. To provide ventilation, the overhead truck door is left open. Because there is no direct access between the tipping floor and the rest of the plant, plant personnel must walk outside to gain access to other areas of the plant. Communication in this area is limited to hand waving and shouting because there are no telephones or intercom systems to the control room. A bell has been installed in the phone system to alert the operator to a call if he has stepped out of the control room.

5.2.3 Platform Scale - NAS Jacksonville

A 50-ton truck scale is available for weighing incoming refuse. Each truck weight is recorded by the truck driver who leaves the truck and enters the scale house to operate the scale instrumentation.

5.2.4 Tipping Floor - NAS Jacksonville

5.2.4.1 General Description--

The 42- × 75-ft concrete tipping floor is used for receiving, storing, and handsorting the incoming refuse. Handsorted rejects are placed in a 8- to 20-yd^3 container stationed on the tipping floor. Approximately 60 percent of the area is required for moving and sorting the refuse, while the remaining area is available for receiving and storing the incoming refuse. A trench drain runs approximately three-fourths of the way down the middle of the tipping floor. Two 4-ft-high walls are available for pushing and storing the waste. A front loader with a 3-yd^3 bucket is used to move and feed the refuse to the processing equipment.

5.2.4.2 Operation and Maintenance--

The tipping floor area was found to be of insufficient size to handle the average 40-TPD design capacity, let alone the expected maximum of 70 tons. At most, the available area can only accept 25 to 35 TPD. The front loader used to move the refuse and feed the processing line is too large to maneuver effectively in the limited work area. However, because much of the waste received was oversized material, it is questionable whether a smaller loader could handle it. The size of the loader and the orientation of the feed conveyor drop chutes to the incinerators also make it impossible to push waste directly into the incinerator feed rams. Instead, the refuse has to be hand sorted and manually loaded. To make floor space available, the refuse has to be stacked as high as possible. The relatively low (4-ft) push wall is not adequate to provide sufficient stacking capability.

The 8-to 20-yd^3 container used for hand sort rejects also reduces the available floor area. Its location on the tipping floor is convenient, but it does take away much needed floor area and prevents use of the second push wall. More labor is required to handle the waste than originally envisioned. A part-time loader operator who also serves as a sorter or operator and at least two other hand pickers are required to handle and prepare the 25 tons of waste for processing in 8 hours. Additional personnel were simultaneously required to operate the industrial shredder and the incinerators. Typical waste receiving, storage, and handling situations are shown in Figures 8, 9, and 10. The tipping floor drain was subject to frequent plugging because of its location directly under the working/storage area. A plate was added underneath the trench bars which stopped the plugging problems.

5.3 PROCESSING - NS MAYPORT AND NAS JACKSONVILLE

5.3.1 General Description - NS Mayport

The delivered waste is hand sorted to remove nonprocessible materials. These materials consist of metals; large wood pieces; bulky items such as

Figure 8. View of as-received waste stored on receiving floor at NAS Jacksonville.

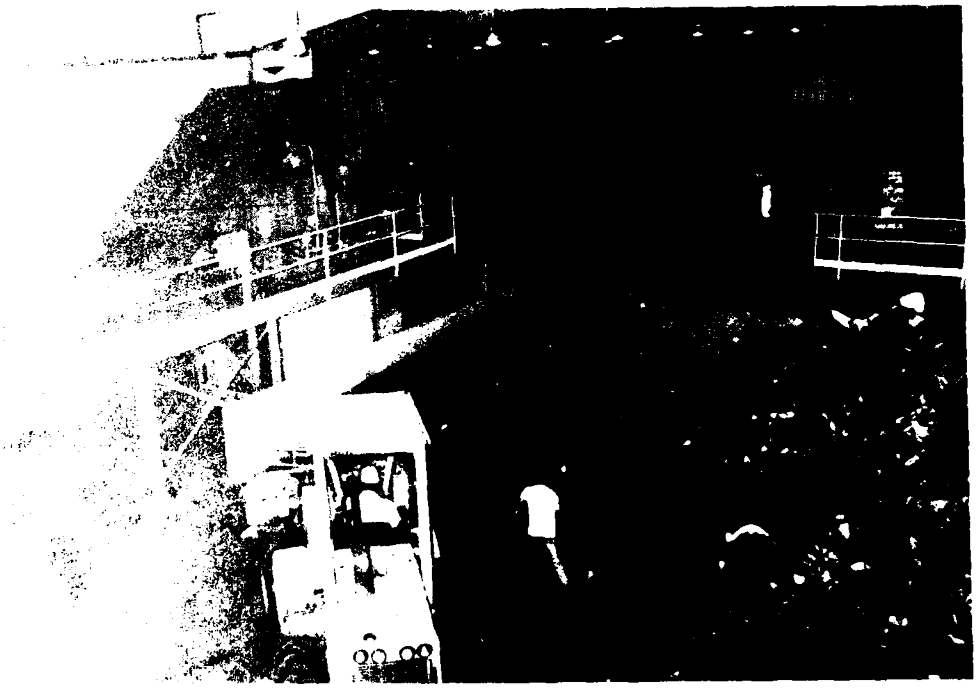

Figure 9. View of hand-sorting process prior to loading waste into the flail mill at NAS Jacksonville.

Figure 10. View of waste overflow into incinerator control panel area at NAS Jacksonville.

carpets and nylon rope; phone books; hazardous materials such as solvent, and paint cans; and live munitions (.50 caliber/20 M), Figure 11. Bulky waste (1 TPW) and metals (2 TPW) are hauled off base by private contractors. The scrap metal generates an income of approximately $100/wk. Wood waste is stored along the side of the tipping floor until enough accumulates to allow burning of wood waste alone. Cardboard is pushed directly into the refuse pit and burned with other wastes or separately.

The sorting process currently occupies two men working for two shifts, 5 days/wk. Two TPH can be processed. A 3- to 4-wk training period is required to obtain an effective and efficient sorter. The process involves one person on the front loader to spread out the refuse. The second person opens all the bags and then sorts for specific items. Previously this work was accomplished by one man on each of three shifts who had to drive the loader, spread out the refuse, and then hand sort for specific items. One man can only process less than 1 TPH but could process enough waste to maintain the incinerator feed rate. The tipping floor is cleaned and washed up to three times/week.

Figure 11. View of hand sorted rejected wastes at NS Mayport that is typical of nonprocessible waste at naval facilities.

5.3.2 General Description - NAS Jacksonville

The processing subsystem was designed to convert the raw waste (5 TPH for 8 hr/day) into a more homogeneous fuel with a reduced ash content and an increased energy value. There are seven equipment systems (five major, two support) in the conversion process. A flail mill, a magnetic separator, a trommel screen, an air scoop cyclone separator, and an industrial shear shredder are the five major equipment systems. The two support systems are a series of belt conveyors, used to transfer waste between the different processes, and a dust collector, which is used to clean the air from the cyclone separator before venting it to the atmosphere.

The first piece of equipment is the twin-rotor flail mill manufactured by Southern Engineering. This mill is only one of three ever built by Southern Engineering. It is used to reduce the size of the incoming waste to a range of 8 in. to 12 in. and to break up boxes and plastic bags. Each of the two rotors is driven by a separate 100-hp motor. This primary size-reduction step is intended to create a more homogeneous waste for improved process effectiveness. The flail mill has a maximum design capacity of 10 TPH with an average of 5 TPH. The size-reduced waste is then passed underneath an air scoop which was intended to remove the lightweight waste fractions and convey them to the cyclone separator, bypassing the trommel.

The remaining waste, supposedly the heavy fraction, goes through a 10-TPH (maximum) Eriez Magnetics 3-stage electro/permanent magnet system which removes ferrous metals. This step is intended to reduce the quantity of noncombustibles in the waste. This unit has a 36-in.-wide belt and is located above the head pulley of the flail mill discharge conveyor.

The waste then enters a 10-TPH (maximum) trommel screen designed to remove the small, heavy waste fraction. This unit is a Sprout Waldron 4-ft-diameter by 8-ft-long rotary screen. This screen has 1/2-in.-diameter holes and is designed to rotate at 12 rpm at a slight incline. Most of the dirt and glass is removed, with the remaining waste joining the cyclone discharged light fraction to be conveyed to the storage bin.

The light waste fraction is intended by design to be collected by the air scoop at the flail mill discharge, enter a deentrainment cyclone separator, and return to the fuel stream after the trommel. Removal of the light fraction at that point in the process line was also designed to improve trommel and magnetic separator effectiveness. A baghouse filter is installed outside to remove dust from the conveying air.

In a separate process line, a 5-TPH (maximum) industrial shear shredder is used to break up any handsorted over-sized waste which can not be processed by the flail mill. The sheer shredder is a twin-shaft, low-speed shredder manufactured by Kleco Shredders Systems, Inc. It was designed to reduce the waste to less than 12 in. in size. The shredder has two counter-rotating shafts that rotate at 60 and 40 rpm, respectively. Each shaft is powered by a 25-hp motor. The discharge of this shredder joins the first process line at the entrance to the ferrous removal magnet.

5.3.2.1 Operation and Maintenance--

The flail mill feed conveyor incline is steep, due in part to the limited amount of space available. Maintenance is difficult due to limited access to the rear bearings and inadequate platforms by the conveyor motors. Dust buildup on the magnetic clutch motor and the flail mill shaft bearings caused equipment failures during 3 yr of intermittent use. The flail mill feed conveyor belt was installed backwards.

The feed hood of the flail mill permitted objects to eject, hit the building ceiling, Figure 12, then land on the tipping floor. An elevated handpicking platform with emergency controls for the complete processing line was never used due to this ejection problem. The spacing of the breaker bars was originally such that items very large in only one dimension could pass right through. Large pieces of cardboard could pass through the mill with only holes punched in them. These large items caused problems in the downstream processing line. The vibrating pan discharge conveyor, Figure 13, located just below the shredder discharge, is only 30 in. wide and cannot move the waste out from under the mill at a high enough rate. Maintenance access is also very limited.

The air scoop and cyclone did not function as intended. The rotary discharge valve of the cyclone is too small, causing frequent jams. The effectiveness of the air scoops was never demonstrated. It was thought that very little material was actually picked up in the scoop. Use of the air scoop was stopped shortly after plant start-up.

The magnetic material separator was reported to be functional and very effective. The trommel did remove most of the small glass and non-magnetic fines. However, the capacity of the trommel was not always sufficient to keep up with the combined output of the flail mill and the industrial shredder. The design of the trommel permitted the discharging waste to fall over and between four structural support members of the rotating barrel. The trommel frequently became jammed by stringy items such as hoses, cloth, computer tape and paper, rope, etc., that became entangled around the barrel support structure at the discharge end.

The shear shredder was originally designed with a single-tooth rotor which was not capable of grasping and shearing some of the items. The unit would jam and did not properly reverse and recycle. As a result, teeth were broken regularly in early operation. Access to the feed conveyor is from one side only, with only 12 in. of clearance to the wall on the other side.

In general, the process equipment cannot keep up with the capacity of the HRI. Space limitations make maintenance access difficult, and the steep incline of the small width conveyors causes refuse spillage which in turn creates further operation and maintenance problems. Housekeeping is difficult due to the layout. During two site visits, the facility was covered with fibrous dust. Even the control panel had dust buildup behind the closed doors. The dust contributed to equipment overheating and failure.

Figure 12. View of damage to building roof over flail mill due to ballistic rejects of the flail mill.

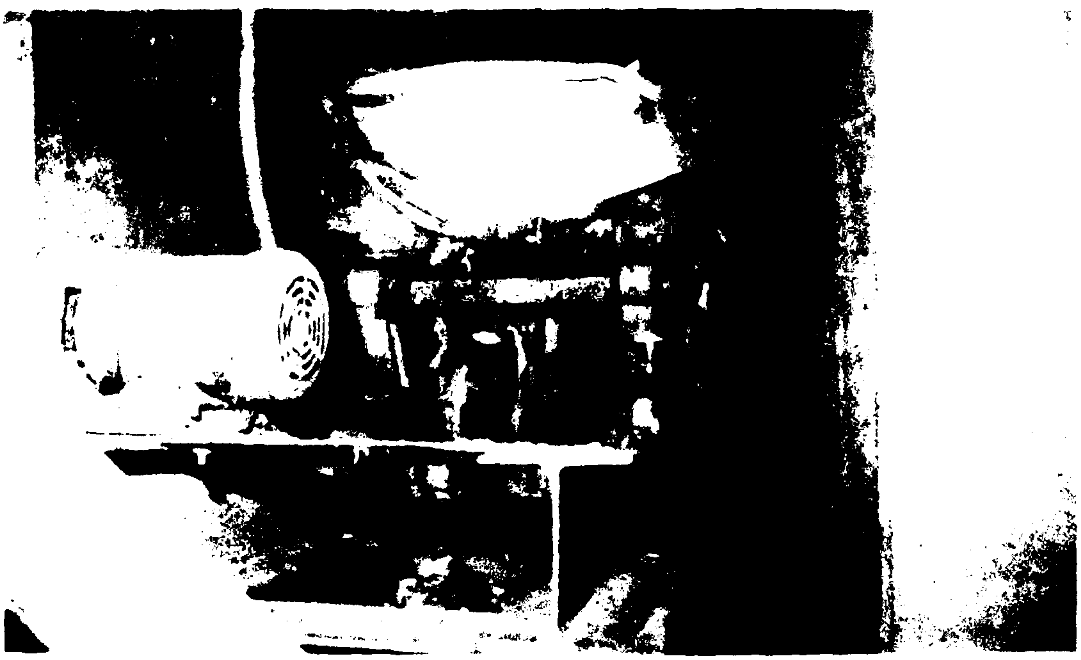

Figure 13. View of small vibrating conveyor beneath flail mill at NAS Jacksonville.

5.3.2.2 Modifications--

To alleviate the problems associated with the initial backward installation of the flail mill feed conveyor modifications were required to some of the structure. The flail mill conveyor motor was replaced with the motor from the industrial shredder feed conveyor since the industrial shredder had a burned out drive motor. Operations with the new conveyor motor have been acceptable. Cross bars and a rubber flap were added to the flail mill feed chute to inhibit the ejection of materials. A positive pressure atomized oil mist lubrication system, Figure 14, was added to eliminate rotor bearing wear, and bars were welded on the V-deflector bars to eliminate the discharge of oversized material. After modification to the flail mill to correct these problems, a throughput rate of only 1.5-TPH instead of the 5-TPH design rate was measured. No known throughput rate evaluation was completed prior to the modifications. Three-tooth rotors have been added to the shear shredder to improve its operations. Presently, one of the shafts needs replacement due to failure of the automatic recycle control. Some of the original inclined rubber belts were replaced with heavy duty multi-ply belts with small surface ribs. The ribs help to prevent the waste from slipping and rolling down the steep incline. The shear shredder and flail mill controls were mounted on top of the elevated platforms of each machine and these are difficult to reach in a hurry. Auxiliary controls were added at the tipping floor level at the base of the platforms. A majority of the processing line interfaces were modified to permit better waste flow and alleviate jams. The flail mill and a shear shredder discharger were enlarged as much as possible. The trommel and shear shredder inlets were reconfigured. Baffles were added to better direct the flail mill and magnetic separator material flows.

5.4 STORAGE AND LOADING OF PROCESSED FUEL - NS MAYPORT AND NAS JACKSONVILLE

5.4.1 Pit - NS Mayport

5.4.1.1 General Description--

After the refuse is hand sorted, the front loader pushes the refuse into the storage pit (Figure 15). The pit is designed to hold 50 tons of sorted refuse, or 24 hours of as-designed incinerator capacity. The pit is approximately 60 ft long × 20 ft wide. A 20-ft-high wall extends along 44 ft of the length of the pit. The wall adds storage capacity to the pit as well as to the tipping floor. The last 16 ft in front of the pit is left open for the loader operations.

5.4.1.2 Operation and Maintenance--

The refuse mixing and pushing action of the front loader tends to cause heavy wear on the tipping floor and tractor tires. The tipping floor also gets wet and slippery from the waste. This condition has caused the loader to slide into the pit.

A significant amount of pit and floor storage is lost because the stacking wall does not extend further along the pit length. In the 16-ft section without the wall, the only effective storage area is the pit depth.

Figure 14. View of atomizing mist bearing lubricator added to the flail mill rotor shaft at NAS Jacksonville.

Figure 15. View of waste sorting process on the tipping floor at NS Mayport prior to pushing into the pit.

5.4.2 Crane - NS Mayport

5.4.2.1 General Description--

The overhead crane system is used to transport refuse from the storage pit to the incinerator feed hopper. It is operated by radio control transmitter from the platform outside of the control room. The transmitter controls the following functions of the crane system: crane-start/off; trolley-north/south; buckets open/close, up/down. A section of the runway beams is structurally separated from the rest of the runway system and is supported through load cells. Signals from these load cells are electronically processed to provide a load weight on a digital indicator in the control room. The weights average 1000 lb/load of mixed refuse, or 600 lb/load of cardboard. The weight measurement is taken when the crane is directly over the feed hopper. The load cell is calibrated periodically against standard weights. The system was provided by the Cleveland Tramrail Florida Company. The clamshell bucket has a 1 1/2-yd^3 capacity. It is cable operated and was manufactured by Erie Stranger. The tram rail was manufactured by Shepard Niles. The maximum trolley speed is 300 ft/min, and the maximum hoist speed is 80 ft/min.

5.4.2.2 Operation and Maintenance--

A preventative maintenance (PM) program has been initiated. To facilitate the crane system PM program, a ladder and crane platform have been added at each end of the runway as shown in Figure 16.

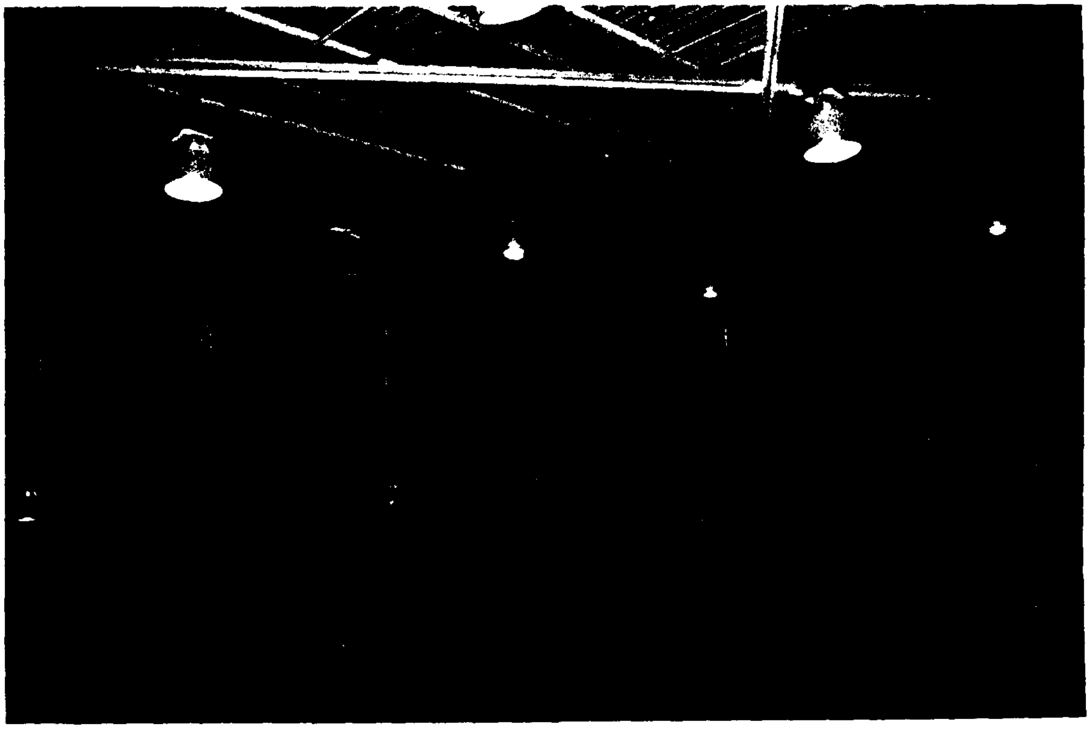

Figure 16. View of new ladder and crane maintenance platform at NS Mayport.

When stationed in the control room, the crane operator cannot see the pit. To compensate, the operator must stand outside the control room on a platform within dangerous proximity of the crane. The limit switches for the crane control have been a maintenance/access problem because they are enclosed within the crane trolley.

Electrical power is supplied to the crane via brushes. This means of power supply is subject to frequent disconnection especially when a heavy bucket load is coupled with a slight sideways motion. To reset the power supply, the operator must climb up onto the crane.

The reliability of the crane suffered because there was no consistent preventative maintenance program the first several years of operation. Since

PM was started and the major gear components were replaced, the crane service has been acceptable. Monthly, the crane is lubricated and the guide wheel rollers and eye bolts are inspected.

Quarterly, the wheels and collectors on the bridge and trolley are checked. Electric brakes, geared drive, and collector in the current conductor bar are also inspected. Semianually, the trolley shoes are replaced, electric motors, controls, and connections are checked. Annually, the handler rods, joints, fittings, end stop, and track are inspected. Other structural frame members are also checked.

5.4.2.3 Modifications--

During construction, the power supply to the crane controls was increased from 60 amps to 100 amps. The brake system was removed by the Navy Public Works Department because of its excessive maintenance requirements. The crane is now stopped by putting the motor into reverse. The crane radio controller was originally powered by batteries which were exposed to dust, creating frequent failures. To eliminate this problem, a plug-in a.c. power supply is now used instead of batteries.

5.4.3 Combustor Loader and Hydraulics - NS Mayport

5.4.3.1 General Description--

The incinerator feed system consists of a ram feeder-hopper assembly which includes a feed chute with hydraulically operated hinged cover doors and a structurally reinforced ram powered by two parallel hydraulic cylinders. The feeder hopper has a holding capacity of 20 yd^3 with the cover doors closed. The feeder ram is controlled by a variable timer and automatically pushes the refuse from the hopper into the furnace. The ram stroke length is controlled to allow for the development of a compressed wedge of refuse between the furnace charging opening and the first hearth to minimize burnback into the feeder hopper.

The ram/hopper was custom designed by the engineering firm of Greenleaf/Telesca. The design had been employed once before at the Eastman Kodak facility in Rochester, New York. The design of the wedge seal throat is referred to as a torque tube.

The hydraulic system was manufactured by Parker. Only a few hydraulic systems were manufactured under this particular design, and Parker has since changed the system design. As a result, spare parts are not standard, and items such as oil filters take a long time to receive after being ordered.

5.4.3.2 Operation and Maintenance--

The charge to the feed hopper usually consists of two crane loads before the feed ram is cycled. The ram cycle is 1.5 to 2 min for household waste, 15 sec for cardboard, and up to 3 min for wood waste or wet refuse. After each feed cycle, the ram retracts then moves forward, sealing the feed throat. Only a few problems with burnback have been experienced. These primarily occur when charging cardboard or wood, neither of which form an adequate seal.

The hydraulic system consists of a single motor and two pumps, one low and the other high pressure. The feed ram motion is started by the low-pressure pump. A pressure sensing device is used to actuate the change to the high-pressure pump, which drives the ram to complete the feed cycle. The PM programs involve weekly cleaning of the ram assembly, lubrication of the wheels, and tightening of all bolts. The hopper doors are also greased weekly. The hydraulic system is cleaned and checked weekly. The motor bearings are checked semiannually.

5.4.3.3 Modifications--

The throat of the feed hopper is cooled with untreated water which is high in $CaCO_3$. This water is not recirculated, and after one pass it is dumped into the residue quench tank. The flow rate is not measured, and there is no current estimate. Because this water is untreated, the residue quench tank is becoming fouled by $CaCO_3$ deposits. It is recommended that an air/water heat exchanger be employed so that softened cooling water could then be employed in the feed hopper and be recirculated instead of discarded in the quench tank. This would reduce the overall plant water consumption.

The feed hopper floor has been rebuilt with 3/8-in. carbon steel plate supported underneath with I-beams. The original configuration sagged because it did not have such support and did not stand up under the weight of the solid waste dropped onto it.

The feed ram assembly has also been rebuilt. The original unit was not square with the feed throat, which resulted in frequent jamming. The wheels were worn severely, and the hydraulic piston and rods were subject to overheating because of their location at the front of the unit. The rod end connections were moved back 8 to 10 in. by adding an I-beam at the front. The hydraulic cylinders were also subject to frequent leaks requiring rod seal replacement. The cylinder bearings and bushings were changed to reduce seal wear. The cylinder was not fully supported at full extension which caused excessive force on the seal. The I-beam addition reduced the needed length of rod extension and thus reduced seal stress.

The original ram guide wheels were made of carbon steel which wore to form flat spots. As a result, the wheels would slide rather than roll. These wheels have since been replaced with cast hard steel wheels. Few jams or operational problems were encountered after the rebuilding and realignment were completed.

Original design and construction omissions on the torque tube are beginning to create problems with this subassembly. No wear plates were provided, and the original metal is thought to have been too thin. The metal is now showing signs of heavy wear, and in places water leaks have occurred. These leaks have been welded where possible. The tube is also warped and the tube base plate has sagged, allowing small items to carry back under the ram. Since the tube is part of the incinerator primary chamber, the tube will be hard to replace/repair.

5.4.4 <u>Storage Bin - NAS Jacksonville</u>

5.4.4.1 General Description--

The final product from the processing subsystem was called a fluff RDF and was conveyed to the storage subsystem which consisted of a storage bin, screw augers, and conveyors to the incinerators. The storage bin, manufactured by Miller Hofft, had a 29-TPD design storage capacity for a waste with a density of 7 lb/ft3. The waste was added to the top of the bin and discharged from the bottom by a pair of counter-rotating screw augers which were designed to traverse the length of the bin. The augers were expected to move an average of 2 TPH or a maximum of 3 TPH of waste onto the conveyors to the incinerator subsystem.

5.4.4.2 Operation and Maintenance--

The storage bin was difficult to operate consistently and/or effectively. Stringy material such as plastic, rags, and hose would frequently wrap around the augers. The diversion plow device, which was intended to distribute the incoming RDF throughout the bin, did not function properly. RDF would become jammed underneath it. The device was removed shortly after start-up. Thereafter, the RDF did not distribute equally along the bin, causing problems with the auger drive system. The uneven distribution would cause the augers to stall or raise up, and the traversing mechanism would end up at a skewed angle before jamming. One of the drive bearings was subject to multiple failures. The designed storage capacity of the bin was questioned but never verified. The operators stated that usually a quantity of refuse sufficient for firing only one incinerator for 8 to 12 hours could be effectively stored in the bin. At an incinerator capacity of 1.0 TPH of RDF, that storage capacity would only equate to 8 to 12 tons. The bin could not be completely filled up because the weight of the RDF would stall the augers. Several times when loaded to the full depth with wet waste, the RDF started to heat almost to the point of spontaneous combustion.

5.4.5 <u>Conveyors - NAS Jacksonville</u>

5.4.5.1 General Description--

Waste discharge from the storage bin is to a 30-in.-wide x 45-ft-long rubber trough-belt conveyor manufactured by Miller Hofft. The conveyor feeds RDF to the incinerator feed conveyor system which is oriented at a right angle to the bin discharge conveyor.

A series of three trough-belt conveyors are employed to feed the incinerators from the storage bin discharge conveyor. Two of these conveyors are reversing to provide delivery to all three of the incinerators.

5.4.5.2 Operation and Maintenance--

The incinerator feed conveyors operated without major problems. However, RDF spillage, dust, waste slippage or carryback, and some jamming did occur.

5.4.6 Combustor Loader and Hydraulics - NAS Jacksonville

5.4.6.1 General Description--

The incinerator feed system for each incinerator consists of a hydraulically actuated ram/feeder-hopper assembly. Each assembly is situated just inside the building in a 15 1/2- x 10- x 7 1/2-ft pit along with the hydraulic power unit and automatic control limit switches, while incinerators are located outside the building. The ram is actuated by two hydraulic cylinders, each having a 55-in. stroke, acting in series for a total ram travel length of 109 in. This puts the ram through an opening in the wall of the building and 38 in. into the primary chamber of the HRI during the charge cycle. The feed hopper has a 3-yd^3 capacity. A flanged lid to the hopper is opened by a single hydraulic cylinder mounted on one side. A guillotine type fire door separates the loader compartment from the primary chamber. Its vertical movement is hydraulically actuated by a single cylinder mounted on the back of the door. The fire door is refractory lined with angle iron across the bottom to seal it. Access to the pit is obtained by lifting several metal floor panels, each weighing an estimated 300 lb (Figure 17).

Figure 17. View of heavy, removable panels over the loading hopper pit at NAS Jacksonville. Hydraulic unit located in the center has been relocated from the pit.

5.4.6.2 Operation and Maintenance--

RDF is delivered to the ram feeder by the incinerator feed conveyors which in turn receive RDF from the storage bin discharge conveyor. The guillotine fire door is lifted, and the ram pushes the RDF 38 in. onto the upper hearth of the primary chamber.

The feed cycle was originally designed to operate automatically. However, having the limit switches located in the pit left them subject to fouling and failures. As a result, the system was ultimately operated in the manual mode. In addition to feeding the incinerators via the conveyor system, waste was often hand-fed directly from the tipping floor. This material tended to be wood and bulky items. Under these circumstances, the fire doors were occasionally used as a crushing mechanism. The angle iron soon came off, and the bottom of the doors bent. This created unwanted air infiltration. The location of the charging door hydraulic cylinder left it subject to heat and flames during the charging cycle.

The pit, containing the ram feeder and hydraulic power unit was exposed to refuse carried back by the ram and dust from the feed conveyors. Along with being difficult to access, due to the weight of the cover doors, there was limited space to perform maintenance on the equipment in the pit. The hydraulic power unit was situated with 3 ft of access on one side and 4 in. on the other side. The valves were subject to fouling from the dust and refuse carryback. Occasionally the material carried back into the pit was burning. Other waste which had spilled into the pit during the loading process ignited and caused fires in the pit. The equipment was damaged by the fire because the ram spray system was out of operation. The loading ram hydraulic hoses were flexible and often dragged across the unit or along the floor. This action caused some of the hoses to wear excessively and eventually rupture.

5.4.6.3 Modifications--

The charge door lifting cylinder was relocated from behind the door to on top of the door. In this location it is no longer subject to heat and flames when the door opens. Many of the flexible hydraulic hoses were replaced with rigid hard piping lines secured to nonmoving anchors. This alleviated the failures associated with ruptured hoses. The hydraulic power unit was taken out of the pit and moved to a location beside the loader pit on the main floor where access was easier and fouling conditions were less prevalent. A disposable filter was also added to the oil return line.

The practice of using the charging door as a crusher was stopped by the supervisors. The incinerator manufacturer recommended using a 1/4-in. silicone rubber flap to seal the charging door and thus reduce air infiltration. This action was taken, but the seal eventually came off during operation, and as with the original angle iron, it was never replaced.

5.5 COMBUSTOR - NS MAYPORT AND NAS JACKSONVILLE

5.5.1 General Description - NS Mayport

The incineration subsystem was built by Washburn and Granger, the mechanical subcontractor, using plans and specifications prepared by the

design engineer, Bertram Reilly, P.E., consultant to Greenleaf/Telesca. The unit was designed to burn waste at a maximum rate of 2 TPH. The waste from the feed hopper is pushed onto the primary combustion chamber by a hydraulic ram. The waste dries and ignites on a refractory hearth and then falls onto a Detroit Stoker grate system to complete combustion at 1400° to 1600°F, releasing gases and turning the waste into ash and residue. The gases enter the secondary combustion where they are retained at 1600°F to permit hydrocarbon combustion. Retention in the secondary chamber also allows particles to settle.

5.5.2 Primary Chamber - NS Mayport

5.5.2.1 General Description--

The primary combustion chamber is designed to liberate 20 × 10^6 Btu/hr. This liberation is equivalent to 2 TPH of the anticipated mixture of Type 1 and Type 2 wastes having a combined heat content of 5000 Btu/lb.

The primary chamber outside diameter is about 10 ft wide and its length is divided into three functional areas: the refractory upper hearth, the grate area, and the residue chute. The refractory hearth consists of five steps each of about 6 in. and a total length of about 11 ft. The ceiling slopes up from the torque tube to about 7 ft in height, at a point halfway down the length. The vertical drop to the grate area is about 3 ft. The reciprocating grate is 8 to 9 ft long and ends in a stationary row of plates along the edge of the residue drop chute. The drop chute is about 3 ft wide and extends the full width of the chamber. The average ceiling height over these areas is about 13 ft.

Refuse, compacted by the ram feeder, enters the primary furnace chamber through the charging opening. As stated earlier, the walls of the charging opening are water cooled to protect it from the furnace heat. Combustion of refuse as it passes through the charging opening is inhibited by the compacting action of the ram. This same compacting action also helps avoid overheating of the charging opening. The refuse is dried and ignited on the inclined refractory hearth located just inside the water-cooled throat. This refractory hearth section was designed with underfire air jets that are no longer in service. The dried partially burning refuse is forced off this hearth by the successive loading action of the feed ram and falls 3 ft onto the grate.

The stoker grate system was manufactured by the Detroit Stoker Company. It consists of alternate rows of fixed and reciprocating cast iron plates in a series of shallow steps. These steps are arranged to provide an overall downward slope of approximately 6 degrees. A single row of nonmoving plates is located at the end of the grate by the ash pit. The grate plates have several rows of 1/4-in. holes to allow air passage up through the plates as well as between the rows. The grates are directly open from below to the residue quench tank/wind box. Grate siftings can fall directly into the quench tank. There have been some minor problems with melted aluminum accumulating on the grate.

A Hauck oil-fired burner, Model No. PRW 112.45, Spec. T5982, is provided in one of the primary furnace sidewalls about 3 ft from the charging opening. The function of this burner is to initially ignite the refuse as it enters the furnace and to aid in drying wet refuse (if required). The burner is equipped with a continuous gas pilot so that waste oil may also be burned.

5.5.2.2 Air Flow--

The combustion air regulation system was designed to operate in the automatic mode with gas temperature at the chamber exit as the controlling set point. As the temperature increased, the air flow increased. However, it was found that the overfire air reached the top of the burning refuse on the first hearth and increased rather than decreased the chamber temperature by causing surface burning of the refuse. Therefore, the air controls are operated on a manual basis, and although each shift operator is permitted to adjust the air flow, they rarely do. The forced air, overfire and underfire, are open about 20 to 30 percent on the damper control setting. Underfire air is injected at the end of the first hearth, at the step, and through the grates.

5.5.2.3 Refractory--

The upper hearth area of the primary chamber has 9 in. of air-cooled refractory brick on the sidewall. The bricks are 4.5 × 9 in. and were specified as super duty firebrick. The brick is backed by 2 in. of insulation. Air is suppled through a 1/8-in.-wide spacer between the brick. The upper hearth is constructed of two layers totaling 9 in. of 4.5- × 9-in. super duty firebrick. The bricks are laid directly on the hearth air plenum. The sidewalls of the grate section have super duty plastic refractory 8 in. thick backed by 2 in. of insulation. The ceilings over both hearths are constructed of 8 in. of super duty plastic refractory backed by 2 in. of insulation. The wall of the chamber facing the secondary chamber is constructed of 4.5- × 9-in. super duty firebrick and is 13.5 in. thick.

5.5.2.4 Operation and Maintenance--

The primary chamber is cleaned weekly to remove the slag buildup. Slag is removed from the steps and walls, and in doing so, some refractory is also pulled off of the sidewalls. Slag buildup is most prevalent below the path of overfire air flow. The throat or transition duct area between the primary and secondary chamber (discussed in the next section) must be cleaned monthly, because slag buildup closes the passage area to less than 50 percent of the free area. The primary chamber thermocouple is located in the sidewall of the throat area, where it is highly subject to slagging. Maintenance access to the primary chamber is very good. Two access doors are provided on each side, above the ash discharge hole. Removal of the slag creates a lot of dust. The plant does not have a dust removal system, so all pieces of equipment are coated with a layer of dust.

The sidewall brick refractory on the upper hearth is air cooled and is in good condition. The grate section sidewalls are plastic refractory and are not cooled, and that refractory is in poor condition. The tuyeres (air injection plenums at the step) were covered by refractory, and grate warpage occurred because cooling air could not be supplied at the base of the step. Slag, which especially forms when the unit is run at high capacity (45 TPD), has pulled off much of the step and sidewall refractory in this area. At the

step or drop-off area, the Public Works Department replaced the original refractory with a plastic refractory that has since worn down to the insulation blocks. This section was replaced with fire brick in April 1984. The refractory around the throat area is also badly worn.

The movement of the stokers is powered by one hydraulic cylinder. This cylinder runs off of the same power unit as the loader hydraulics. The drive mechanism is located inside the chamber, underneath the grates. The cylinder itself is located outside the chamber, where it is fastened to a pipe rack. The speed is varied to maintain adequate burnout. There have been relatively few problems related to the hydraulics or control mechanisms. A preventative maintenance program has been initiated for the stoker cylinder. To relieve the wear caused by dust accumulation, the cylinder is cleaned regularly. All of the grate elements were replaced after 3 years of operation. Only a few grate elements were replaced prior to this. The wear on the elements was uniform down the length of the grate.

5.5.3 Secondary Combustion Chamber and Burner System - NS Mayport

5.5.3.1 General Description--

The gaseous products produced from the refuse combustion in the primary chamber pass over the bridge wall at the far end of the primary combustion chamber (opposite from the charging opening). The gases are then immediately forced downward by a refractory baffle separating the primary and the secondary combustion chambers (Figure 18). Another oil burner, also manufactured by Hauck, is located in the sidewall of the bridge wall-baffle passage. While this afterburner is primarily intended as a means of recovering energy from waste oil, it also was designed to achieve complete combustion of the gases from the primary chamber. The mixed products of combustion from the primary chamber and the burner are detained in the large refractory-lined secondary combustion chamber. This secondary chamber was designed for an average retention of 3 sec to ensure complete combustion of gases and to allow the large particles to settle out. The secondary chamber inside dimensions are about 10 ft wide, 21 ft long, and 18 ft high. The baffle wall extends down into the chamber about 8 ft. The 3- × 6-ft discharge opening is located 12 ft above the floor.

5.5.3.2 Burner System--

The location of the secondary chamber burner was changed twice during the final design of the system. Currently it is spaced relatively close to the bridge wall. If the burner is operated at its maximum capacity, the flame may impinge on the opposite wall. It was moved to this location to improve gas mixing and to allow all the gases from the primary chamber to pass through the flame. Waste oil is now burned less than 50 percent of the time. It is usually burned only when there is no refuse available. Oil consumption averages 50 gal/hr, with the maximum being 80 gal/hr while previous consumption was much higher. The annual consumption is now approximately 6000 gal/yr, while previous consumption was much higher. Oil is drawn from one of two 6000-gal capacity tanks. Two tanks are needed because the suction lines are located 20 in. from the bottom of the tank, so only one half the capacity of each tank can be suctioned out. The public works department uses a suction truck to pump out the remaining oil (settlements) as required. Each

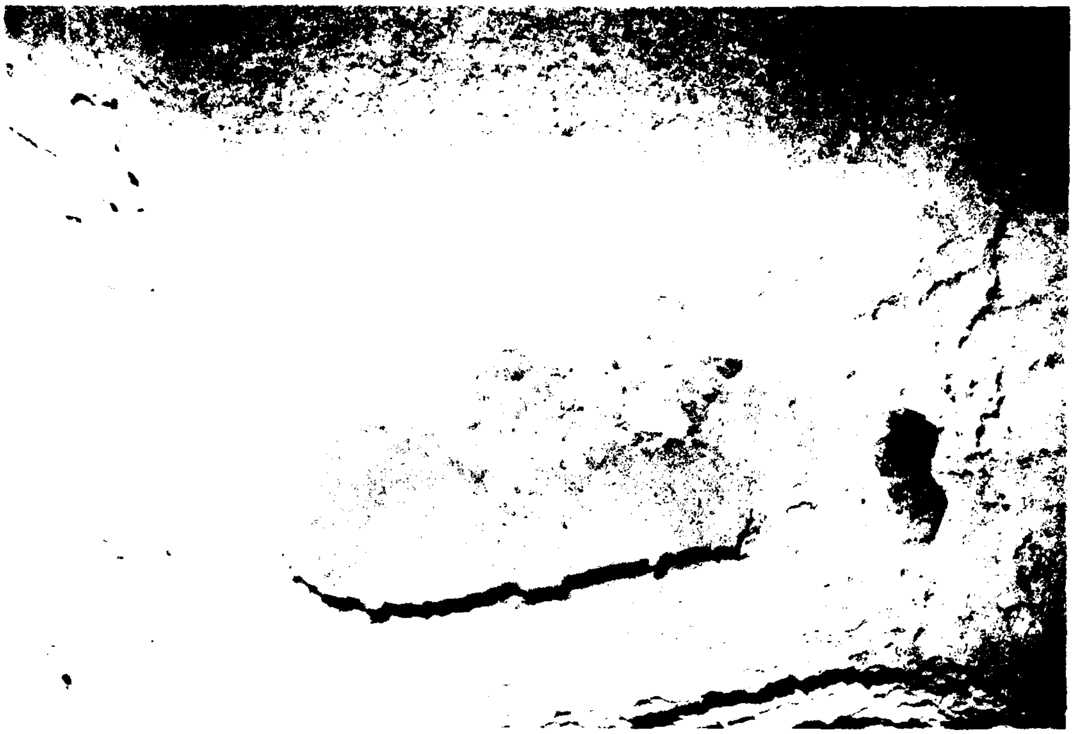

Figure 18. View looking up into entrance from primary chamber to secondary chamber showing burner port at the right at NS Mayport.

tank has two pumps, each with a single in-line filter. Piping permits crossover pumping and filling of one tank from the other. There are no burner controls located in the control room. Rather, the only controls are located at the combustion chamber. The burner was designed to automatically cycle off at high chamber temperature. However, in the control room there is no indication of whether the burner is on or off. Therefore, the auto cycle is not used.

5.5.3.3 Refractory--

The secondary chamber has 8 in. of super duty plastic refractory on the walls, floor, and ceiling. All the refractory is backed by 2 in. of insulation. The wall of the chamber facing the primary chamber is constructed of stacked 4.5- × 9-in. super duty firebrick and is 13.5 in. thick. The baffle wall hanging down from the ceiling is covered with 8 in. of super duty plastic refractory and 2 in. of insulation. The entrance duct from the primary chamber is a brick arch over the two standing brick walls.

5.5.3.4 Operation and Maintenance--

The walls between the primary and secondary chamber are made of loose stacked firebrick, separated by a 12- to 18-in. gap to provide heat release. Several of the secondary chamber wall bricks have moved, resulting in a concave wall. This in turn resulted in the formation of several leaks, which have been patched with plastic refractory if they could be reached. However, several gaps still exist and are the source of gas and fly ash emissions when the chamber pressure becomes positive.

Slag accumulation must be removed weekly from the baffle wall at the throat and the settling chamber at the end of the secondary chamber beneath the gas exit. Settled fly ash in the chamber is also removed weekly. A new floor of plastic refractory has been put down. Preventive maintenance is performed weekly on the burner. The burner air flow valve is cleaned and lubricated. The oil filter is rotated and the flame scanner is cleaned. Semiannually, the burner is disassembled and inspected.

Maintenance access to both the secondary chamber and the burner is good. There is a large, ground-level access door to the secondary chamber and an adequate platform to access and work on the burner.

5.5.3.5 Modifications--

The burner controls were mounted on the chamber wall and became excessively hot due to the wall heat. The burner control panel was removed and remounted on stand-off plates to permit cooling air to flow behind the panel.

During the facility's acceptance test, some light smoke was observed exiting the stack. To eliminate the smoke, changes were made in the transition throat between the primary and secondary chamber. After April 1979, the throat was reduced in size, and a stack of firebrick was laid across the top of the arch. The intent was that the small throat area would double the gas velocity through that area and aid the mixing process. The bricks would also cause turbulence and aid in mixing. In practice, these changes did not eliminate the smoke, and they were removed shortly afterward.

5.5.4 General Description - NAS Jacksonville

There are three separate and identical combustor units. These are packaged modular units which were designed and built by Comtro Division of Sunbeam Corporation. The incinerators have two cylindrical chambers, one on top of the other. The lower or primary chamber is intended to be operated in the starved-air combustion mode and to generate a low Btu flue gas that is combusted in the excess-air secondary chamber. The primary chamber uses the feed ram and two internal pusher rams to move the refuse and residue along the three-step refractory hearth to the wet quench tank at the very end of the chamber. The system is designed to reach and maintain independent set temperatures in the primary and secondary chambers. Air flow control, feed rate, and auxiliary fuel oil burners are the means used to control the chamber temperatures.

The units were designed to burn both processed and as-received waste. One of the two auxiliary oil burners of the secondary chamber was designed to burn waste oils as an alternative to No. 2 fuel oil.

5.5.5 Primary Chamber - NAS Jacksonville

5.5.5.1 General Description--

The cylindrical primary chamber is approximately 18 ft long and 8 ft in inside diameter. The refractory hearth is divided by steps into three sections. The first hearth is at the same level with the feed hopper ram and is about 5 ft long, 8 ft wide with a ceiling height of approximately 5 ft. A step of 12 in. separates the first hearth from the second, flat hearth, also about 8 ft wide but about 1 ft longer than the first hearth. Its ceiling height is about 6 ft. An 18-in. step separates the second hearth from the third hearth. The third hearth is narrower than the first or second hearth due to the curvature of the round chamber wall and is equal in length to the second hearth. The ceiling height here is about 7.5 ft.

Waste is moved along the first hearth by the action of the feed-hopper ram which enters 38 in. into the chamber. The second and third hearth also have rams to move the waste and residue along the hearth. These rams are located under the air plenums and are normally retracted from the chamber. The hearth rams are both 6 in. high and 3 ft wide. The rams are constructed of angle steel framing and are refractory filled on their face and along their top side. Each ram is actuated by two hydraulic cylinders in parallel and guided by two pipes located in a frame beneath the unit. The cylinders are accessible only from underneath the loader and only after the removal of the end plate of the frame. There is no access to the rams from the pit below the primary chamber.

The second of the internal rams removes the residue from the chamber by pushing it over the third hearth into the quench tank via a 4- × 1-ft refractory-lined drop chute located in a 4-ft-long × 4-ft-wide × 6-ft-high extension on the back of the primary chamber. The back wall of the extension is a 4- × 6-ft maintenance door that swings 180 degrees to permit access into the chamber. The door is refractory lined and has a high temperature seal around the door to reduce air infiltration. This door is held shut by two clamps.

There were originally two burners located on opposite sides of the primary chamber. Each of these primary chamber burners are rated at 1.0 MBtu/hr and utilizes No. 2 fuel oil only. A 1/3-hp motor at each oil burner serves to move air as well as to pump oil into the burner.

5.5.5.2 Air Flow--

The underfire air supply is designed to pass air up from large slots in the plenum through the small cracks between the brick. There is no overfire air fan, however, some overfire air is supplied through the primary chamber burner opening. Underfire air is supplied by a forced-draft, combustion-air fan that is also supplying the secondary chamber. The single supply duct to the primary chamber from the fan has an automatic butterfly damper. The duct then divides into three small ducts, one to each hearth level. The small

ducts each have a manual butterfly damper. The amount of underfire air is designed to be a function of temperature in the primary chamber. A single thermocouple in the side wall of the flue gas exit duct provides the only temperature reading and control function. A second control point was the chamber pressure. A Photohelic brand gauge was provided to sense the chamber pressure and control the underfire air damper closed if chamber draft decreased past the positive pressure side setpoint. Once chamber pressure returned to a sufficiently negative value, past this setpoint, control of the underfire air damper reverts back to the temperature controller. Although the Photohelic gauge also has a control setpoint for too much draft or negative pressure, this control capability is not connected, as there is no capability (other than the simply counterweighted barometric damper) to limit excess draft.

5.5.5.3 Refractory--

Each hearth is constructed of firebrick and refractory over an underfire air plenum. In addition to the 4-in.-thick brick in the hearth, the primary chamber is lined with 2 in. of insulating mineral wool and 4 in. of castable refractory with a service temperature of 2500°F.

5.5.5.4 Operation and Maintenance--

The feeder ram pushes a charge of refuse approximately halfway onto the upper hearth. Successive loads push the preceeding charges forward until they fall onto the second hearth. The first internal ram pushes the burning refuse forward off the second hearth to the third hearth, the final combustion zone. At this point the material, predominately ash, is pushed into the drop chute to the water quench tank by the second internal ram. After each cycle, the rams retract to their position underneath the hearth. The rams are shown in Figures 19 and 20.

As the rams retracted, they tended to carry ash back into the ram box. After a time, the box would fill with ash thus prohibiting the ram from fully retracting. Slag, melted metal, and bolts were the most common materials jamming under the rams. Either of these conditions left the rams exposed to the chamber temperatures, causing them to warp. The rams were removed and straightened, only to warp again. The second internal ram was especially subject to this situation because of its long stroke and because it was moving through an area with a higher concentration of ash and slag. To correct this condition, the ram box had to be cleaned out. It is suspected that because of the frequent removal of the back plate and because the air seal and packing became worn or were not replaced, an area for uncontrolled air infiltration was presented.

Although the design provided for automatic control, these internal rams were operated manually. Manual operation was employed because the limit switches of the internal rams were connected to the feeder ram auto-load cycle which function was disconnected because of other problems. Furthermore, the rams were not large enough to clean the entire hearth. About 12 in. of hearth on either side and an unknown length at the end of each hearth could not be reached. This undisturbed area permitted residue buildup. The walls of the chamber are curved, and the residue was also able to pile up along the lower curvature. These areas all became covered with slag and clinkers,

Figure 19. View inside primary chamber showing damage to hearth, step, ram, and charging door refractory, NAS Jacksonville.

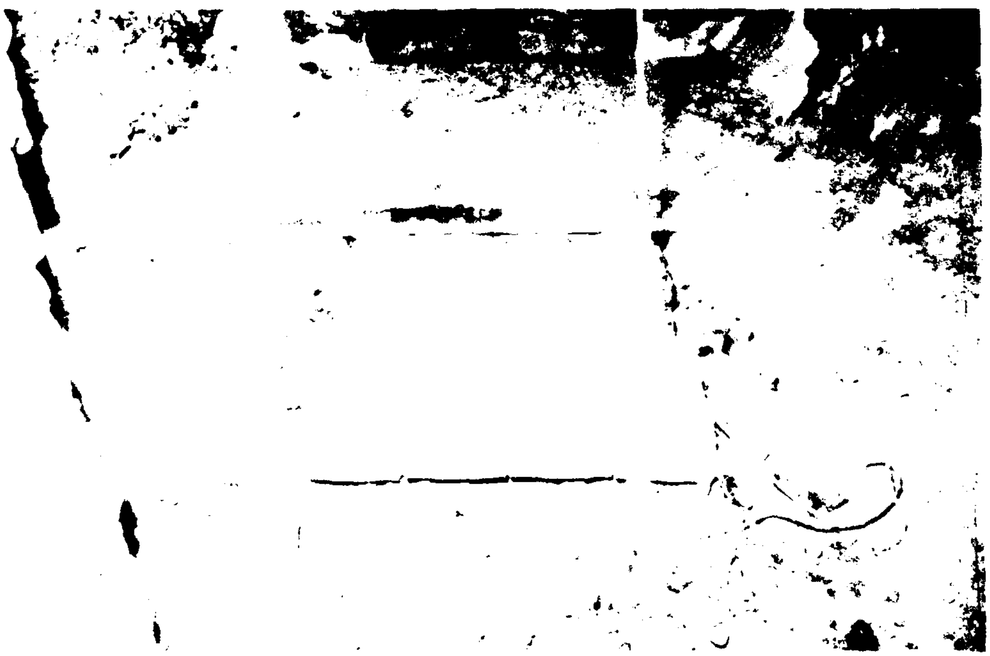

Figure 20. View inside primary chamber showing internal transfer ram stuck in the full forward position, NAS Jacksonville.

removal of which also caused the removal of the refractory. The internal rams were designed to slide on silicone carbide rails, two rails for each ram, not on the hearth brick. These rails showed extreme wear but were still functional. Problems with the rams and the sidewall slag are illustrated in Figures 21 and 22.

Figure 21. View inside primary chamber showing damage to the internal steps, NAS Jacksonville.

Although the design called for two burners, there actually was only one functional burner. The second burner was completely installed before realizing there was no hole through the refractory for it into the primary chamber. Therefore, this second burner was used for spare parts. The functional burner was originally mounted with protection from the outside environment. However this shield was soon nonfunctional due to frequent removals, and the burner was subject to rain as well as to the drainage from the building gutters. As a result, it soon rusted. The burner has its own air supply that ran continuously to cool the burner frame to prevent burnout. The mount permitted outside air to enter around the burner to provide cooling to additional parts of the burner. This was another area of uncontrolled air infiltration.

Through the course of operations, the rear access door in the extension to the primary chamber warped. This created another area of uncontrolled air

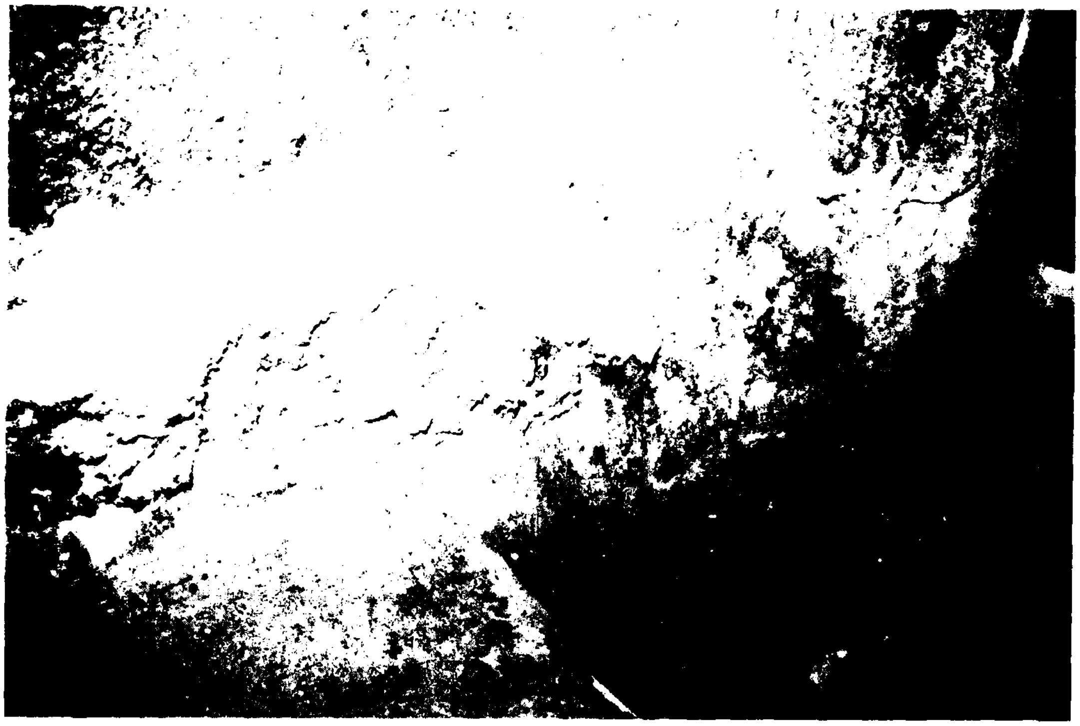

Figure 22. View inside primary chamber showing the line of slag buildup on the refractory wall, NAS Jacksonville.

infiltration. The door was removed, straightened, and reinforced by adding steel plates; but the door air seals were not maintained. A small viewing door was removed from the large door, and that opening was sealed.

The residue drop chute appeared on the construction drawings as being refractory lined. In actuality it was simply a stainless steel chute which eventually overheated and warped severely. The chute was subject to damage caused by clinkers catching in the drag chain. It was therefore replaced with a refractory-lined chute to the water level.

A large pit was provided for access underneath each incinerator. However, access to the pit was difficult, as there are no stairs and the operators had to squeeze past the residue conveyor tank. Additionally, no parts are accessible from underneath the incinerator. All the parts are completely sealed and can only be accessed from inside the chamber or from the separated space under the ram loader.

The primary chamber was designed to operate in the starved-air mode at a temperature of 1600°F and a negative pressure of about 0.25-in. H_2O. However, the negative draft was usually observed to be 0.3- to 0.4-in. H_2O during boiler operation and 0.25-in. H_2O during natural draft operation on

the by-pass stack. The temperature was usually reported over 2000°F. The high negative pressure drew in uncontrolled air from the burner mount, the rear access door, the internal ram box, the guillotine fire door, and other pathways, including possibly the drop chute. This uncontrolled air entered at volumes great enough to create excess-air conditions and high (2000°F) primary chamber temperatures.

The temperatures and pressure in the primary chamber were designed to be controlled by three functions: feed rate, air flow, and the auxiliary burner. The burner was not used after start-up since the chamber temperature was easily kept over the low set point. The underfire air supply was reduced as the temperature increased. However, due to the uncontrolled air leakage, the primary chamber gas temperature was frequently above the high temperature set point, and therefore, the modulating underfire air damper was usually set to its minimum possible air flow. Zero air flow was not possible due to leakage around the butterfly dampers in the air supply ducts. If pressures above the set point (positive pressures) were to occur in the chamber, the air supply damper was also ordered shut. The third control function, feed rate, had already been manually overridden by the operators when they bypassed the auto-load cycle to avoid auto control problems with the loader. Although the operators could feed whenever they wanted, they tried to follow a timed interval and feed a constant volume amount. The interval and volume were determined through experience. The goal was 1 TPH. If a feed cycle time or volume was missed, the temperature control would be lost due to the reduced fuel-to-air ratio. High chamber temperatures would then result and could usually not be lowered. This was especially difficult because of the previously noted problems with maintaining feed rates from the storage bin and by hand loading.

The high temperatures caused fly ash slagging on the transition duct to the secondary chamber and caused slag clinkers to form on the hearths. Removal of the slag on the hearth and sidewalls also caused the removal of refractory since the slag adhered to the refractory. Had the temperature been controlled there would have been problems maintaining the underfire air supply. The air plenums beneath the hearths were not accessible from outside the incinerator. To remove the fine ash and slag that settled down between the bricks and into the plenum required the removal of the hearth brick. This process was difficult and time consuming. If this cleaning were not done weekly, the air supply cracks between the hearth bricks would become plugged.

5.5.6 Secondary Chamber - NAS Jacksonville

5.5.6.1 General Description--

The secondary chamber is cylindrical, refractory lined, and is positioned above the primary chamber. Combustion products flow up from the primary chamber through a 6 1/2-ft × 26-in. retangular transition duct and are then directed 90 degrees through a constricted (36-in. diameter) throat area. The throat area then opens up to the approximately 8-ft-inside-diameter secondary chamber. There is a Photohelic pressure sensor in the exit of the secondary chamber. The gauge on the control panel indicates the second chamber draft but does not control any functions. This chamber is intended to operate in the excess-air mode. The gases entering the chamber should be at

approximately 1600°F and have a fuel value from the uncombusted hydrocarbons. Controlled volumes of air then are introduced to the chamber in quantities sufficient to completely combust the flue gas, release the associated energy, and raise the gas temperature to an expected 1800°F.

5.5.6.2 Air Flow--

Combustion air is introduced from a modulated air plenum to three different locations of the constricted throat area. Air is introduced: (1) perpendicular to the gas flow through 2 1/2-in.-diameter holes which are located around the throat area, (2) tangential to the gas flow through 4-in.-diameter holes located in the transition area of the throat and secondary chamber, and (3) parallel to the gas flow through 1- × 10-in. slots located around the perimeter of the chamber. Manual and automatic dampers are used to control the air flow. The automatic damper is temperature modulated against a desired 1800°F set point. If the temperature rises above the set point, more air is added to cool the flue gases. If the temperature drops, the air flow is reduced to maintain or raise the flue gas temperature.

5.5.6.3 Burner System--

The secondary chamber has two burners: the main burner and the pilot burner. The main burner was rated at 1.54 MM Btu/hr and fired either No. 2 fuel oil or waste oil. The pilot burner is rated at 0.84 MM Btu/hr and fires only No. 2 fuel oil. The burners had light metal hoods designed for protection from the outside environment.

5.5.6.4 Operation and Maintenance--

In actual operation, the degree of uncontrolled air entering the primary chamber created completely combusted gases with temperatures often at or above 2000°F. Liquidified slag ran down the transition duct (Figure 23). Upon exiting the secondary chamber, the gas temperature was low enough to signal the automatic damper control to shut. However, the dampers do not form an air-tight seal and even in the closed position allow air to enter the chamber. This added air coupled with the near-zero fuel value gases from the primary chamber led to a condition wherein the secondary air was acting only to cool the hot gases. As a result, the secondary chamber often ran at approximately 1600°F or lower at the exit duct.

The throat area from the primary chamber was heavily slagged over and the 2 1/2-in.-perpendicular air injection holes were not visible. This is a result of the high temperature and fly ash content of the gas stream from the primary chamber. The refractory throughout the secondary chamber appeared in good condition, with no spall, slag, or large cracks. However, the floor area underneath the dump stack was worn in a circular pattern because the dump stack allowed rain to enter into the stack and fall onto the chamber floor.

Fuel oil was burned in the pilot burner during the start-up and the burndown cycles. It is believed that the pilot burner is/was hi-lo fire and did not normally control below-low fire, except perhaps above the secondary high-temperature-alarm setpoint which was not observed being reached in operation. Originally the oil pressure was set at 250 psi which was difficult to control and to match to the air flows. As a result, oil would frequently blow back onto the burner and catch fire. Even though the burners were

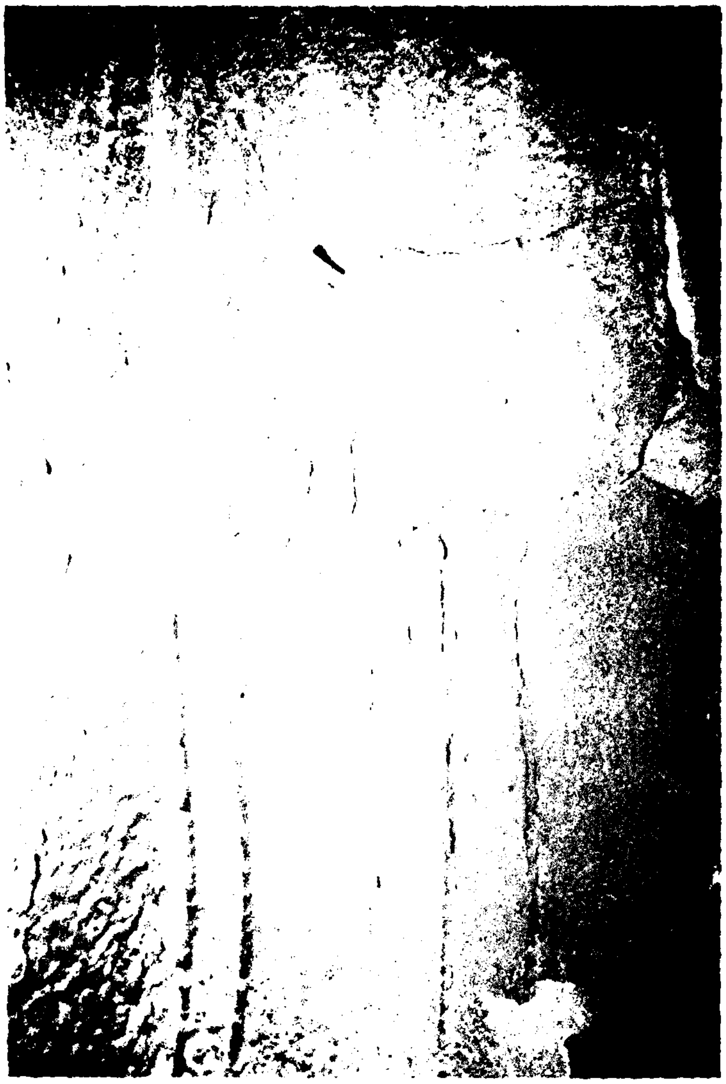

Figure 23. View inside of exit duct from primary chamber to secondary chamber showing thermocouple location and lines of molten slag, NAS Jacksonville.

covered, rain still came in contact with them and rusted out several of the cast iron components of the burners. During the operating time, six burners had to be replaced. Further complications with operating the waste oil burners were due to the quality of the waste oil and the inadequacy of the pumping system. The oil contained large quantities of contaminants which would clog and blind the filters within a short period of time. Burning of waste oil was discontinued shortly after start-up.

5.5.6.5 Modifications--

One of the burners was modified by replacing the cast iron components with cast aluminium parts which would not be susceptible to rusting. To reduce or eliminate oil blowback onto the burners, the oil pressure was reduced from 250 psi to 150 psi, and larger nozzles were installed.

5.6 STACK SYSTEM - NS MAYPORT AND NAS JACKSONVILLE

5.6.1 General Description - NS Mayport

The discharge from the ID fan is connected to the free standing main stack through a short breeching. A second refractory-lined stack, the flue gas dump stack, is located between the secondary combustion chamber and the boiler inlet. This dump stack is utilized when there is no need to generate steam or if there is a maintenance problem in the boiler, air pollution control, or ID fan systems. The dump stack has a cap that is held closed during normal operation and can be opened when one of the aforementioned situations occur.

5.6.2 Dump Stack - NS Mayport

5.6.2.1 General Description--

The dump stack is located in the building and passes through the roof. The 50-ft-high and 6-ft-4-in.-O.D. stack is constructed of steel and lined with 4 in. of refractory and 2 in. of mineral wool insulation. A 1.5- x 3-ft personnel access door is located in the base. The top of the stack is approximately 15 ft above the building roof and contains a cap to close the stack. The cap is constructed of steel and is lined on the flue-gas side with 4 in. of castable refractory. A 3/8-in. steel cable is fastened to the cap and is led down the stack to the base. A small hydraulic cylinder is used to power the cap closed.

5.6.2.2 Operation and Maintenance--

The dump stack cap is operated by the hydraulic system just described that permits the cap to open should a power failure or low boiler water condition occur. As a result, the hydraulic system must be operated even when waste oil only is being fired. The control can be changed to an electric solenoid so that the hydraulics can be shut off during periods when burning only waste oil. Leakage of air down the stack is suspected. The stack cap seal has been replaced several times. The metal frame was rebuilt after it warped.

5.6.2.3 Modifications--

The counterweight system on the dump stack cap has been replaced twice. Each time a different design was employed. Problems were due to the pivot point, the amount of counterweight, and the cable connection. The final modification apparently solved the problems, and the cap is now functional.

5.6.3 Boiler Stack - NS Mayport

5.6.3.1 General Description--

The 75-ft-high, 4-ft-8-in. outside boiler stack is constructed of steel and is lined with 4 in. of refractory. The stack is located within the building and passes through the roof. A 2- × 3-ft personnel access door is located in the base.

5.6.3.2 Operation and Maintenance--

There have been no problems or required maintenance associated with the NS Mayport boiler stack.

5.6.4 General Description - NAS Jacksonville

Each incinerator has two stacks. One stack, the dump stack, is used to bypass the flue gases from the boiler when the boiler and auxiliary equipment is not operational. The second stack, or boiler stack, is used only when the boiler is operating. Flue gas then passes from the boiler through the ID fan and up the stack.

5.6.5 Dump Stack - NAS Jacksonville

5.6.5.1 General Description--

The dump stack is refractory lined and has a spark arrestor screen. The stack is supported by the incinerator, extends approximately 10 ft above the building roof line, and is 48 in. in diameter. It is located at the discharge end of the secondary chamber, approximately 5 ft from the building. A short, square duct tees from the base of the stack to the entrance of the boiler.

An electrically operated butterfly damper is located inside the dump stack. This damper closes if the flue gases are to be directed to the boiler for steam production.

5.6.5.2 Operation and Maintenance--

The butterfly damper is controlled according to the steam pressure in the boiler. Under conditions of decreased steam demand, the damper opens. This allows the flue gases to exit through the dump stack, thereby bypassing the boiler. Working in conjunction with the dump stack damper is a boiler exit damper. As the steam pressure is met, the exit damper closes as the dump stack damper opens. This pressure control function did not work properly. Several problems occurred in the electrical control circuitry, and the damper shafts and bearings would not rotate.

The dump stack damper does not form a tight seal when it is closed. This creates problems: it creates a source of uncontrolled air infiltration as the negative pressure pulls air down the stack, and it allows water (rain) to

drip onto the floor of the secondary chamber. Such dripping has formed a depression in the refractory.

The exterior of the dump stack is heavily rusted. Although it is refractory lined, the surface still gets too hot to hold paint. Rusting is further accelerated by the local climatic conditions.

5.6.5.3 Modifications--

Bearings were replaced and modified on one of the dump stack dampers.

5.6.6 Boiler Stack - NAS Jacksonville

5.6.6.1 General Description--

The boiler stack is constructed of light gauge metal and has a weather cap. The boiler stack is supported by the exit duct of the ID fan which, in turn, is mounted on a platform at the far end of the boiler platform. The boiler stack extends approximately 10 ft above the building roof line and is about 18 in. in diameter.

5.6.6.2 Operation and Maintenance--

The boiler stack is used only when steam is being produced. The flue gas is pulled through the boiler by the ID fan and then exhausted up through the stack.

The boiler stack has functioned as expected without any operational or maintenance difficulties. Since the flue gases are cooled by the boiler to about 500°F before they exit through this stack, its surface can hold paint. Therefore, unlike the dump stack, it is not susceptible to rust.

5.7 BOILER AND AUXILIARIES - NS MAYPORT AND NAS JACKSONVILLE

5.7.1 General Description - NS Mayport

From the secondary chamber the combustion gases enter an Eclipse, waste heat recovery, single-pass, fire-tube boiler. This boiler has a surface area of 4426 ft^2 and is designed to reduce gas temperatures from 1600° to 500°F at 4000 SCFM. Its capacity is 14,184 lb/hr of 250 psi saturated steam. There are approximately 450 to 500 2-in. tubes arranged in rows (Figure 24). Each end of the boiler is easily opened to permit full access for cleaning of the fire side of all tubes (Figure 25).

The system was designed with a continuous and intermittent blowdown system. The continuous blowdown system has a water/water heat exchanger to cool the blowdown before discharge. The cooling water is provided by the boiler makeup water to permit recovery of some energy. A second cooling system was placed on the continuous blowdown system to lower the blowdown water temperature enough to permit the use of an in-line meter to measure the blowdown flow. This cooler was later removed, as was the meter, to reduce water consumption.

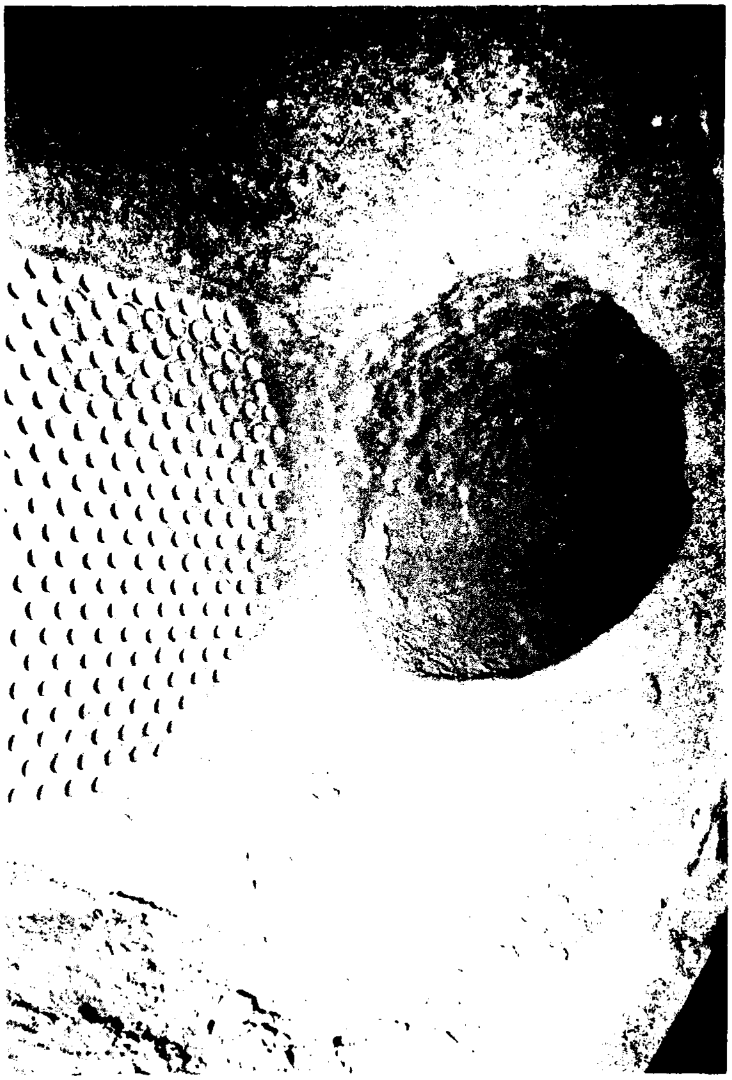

Figure 24. View of flue gas entrance duct from incinerator to boiler, NS Mayport.

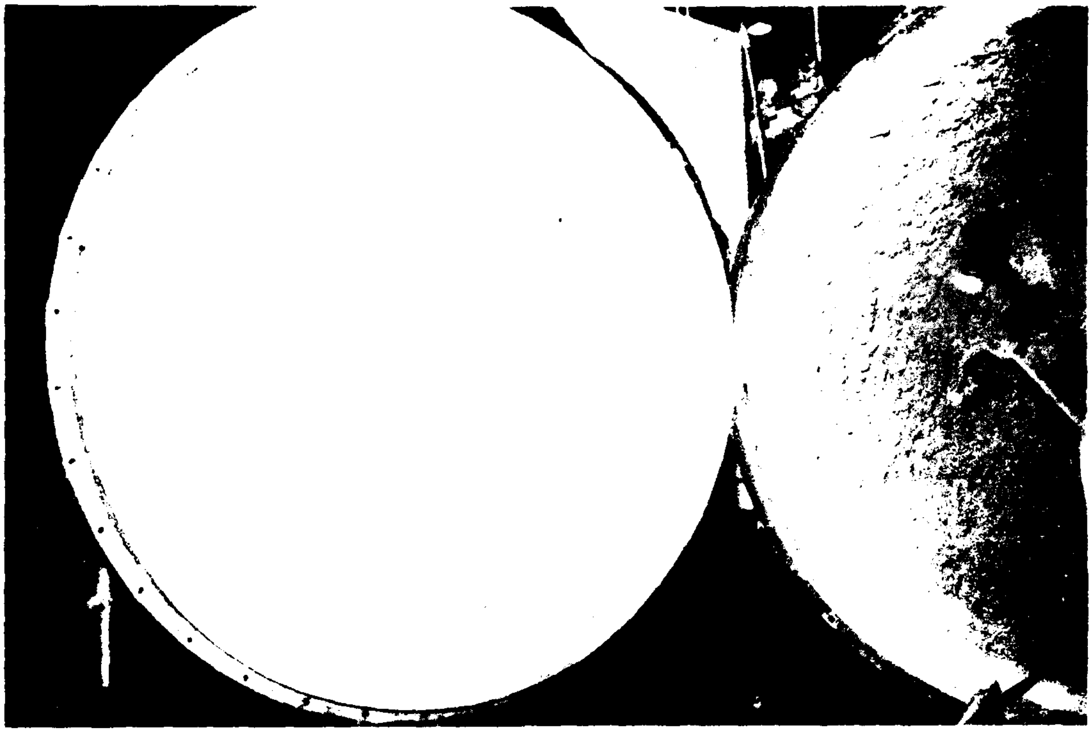

Figure 25. View of boiler front access door open during cleaning, NS Mayport.

5.7.2 Auxiliaries - NS Mayport

5.7.2.1 General Description--

The makeup water is supplied by the station from their central water distribution system. The water is processed through a softener to lower the high $CaCO_3$ content and then treated with phosphates and sulfites to maintain boiler water quality as required by water chemistry tests performed each shift. The water is stored in an elevated 5-ft-diameter by 8-ft-long deaerator (DA) tank. About one-half of the capacity of the tank is available for storage. Low pressure steam heats the water in the DA tank to 180°F. Two boiler feedwater pumps are located below the DA tank. The pumps are connected to an auxiliary power supply in case of electric power failure so that water can continue to be delivered to the boiler. Only one of the pumps is required at any time, and the pumps are used alternately on a weekly schedule.

5.7.2.2 Operation and Maintenance--

The boiler is generally run at 200 psig, although it is rated at 250 psig. The boiler inlet temperature ranges from 1500° to 1700°F and the outlet temperature, from 450° to 550°F. The outlet temperature tends to increase towards the end of the operating week due to particulate fouling of the boiler tubes. The boilers can be operated at a maximum of 2 wk before

shutdown for cleaning is mandatory. Prior to start-up each week, the low water and other boiler alarms are checked, and the feedwater pumps are lubricated.

The boiler fire-tubes have been rerolled once by the contractor. Seven upper rows of boiler tubes warped due to low boiler water and had to be replaced. The refractory on the inlet side has been replaced once. Slag that occurs here does not pull the refractory off. Bottom blowdown had been done on an hourly basis, but that practice has been discontinued. Instead, the boiler is totally drained every 3 mo. The water side is also cleaned at that time, and the manholes are replaced. Weekly fire side tube cleaning requires approximately 5 hr, and typically an average of three to five 1-gal buckets full of ash/slag are removed. The boiler requires approximately 3400 manhours of preventive maintenance per year. This work is done by the operators and labor staff, not maintenance personnel.

5.7.2.3 Modifications--

The feedwater pumps were a major source of failures in the past. The original pumps had problems with the thrust bearings. Water hammer, occurring when the pump stopped, broke the seals. One new pump was installed in 1983. The boiler water level and pump controls were also replaced. The original system of pump on/off control allowed the boiler to empty to 3 in. of water in the sight glass before turning the pumps on. In one instance the feed pump failed to start when the boiler level reached this critical level. The low water alarm sounded, but the dump stack did not open. As a result, the water was boiled out of the boiler. In most other instances the pumps would start up and increase the boiler water level appropriately. However, a large volume of relatively cold feedwater (180°F) would shock the boiler and reduce the steam output momentarily. Furthermore, by allowing the water level to get so low, the steam quality was decreased. With the new pneumatic level control system, one pump is run continuously with a recirculation loop to the DA tank. The boiler supply line now has a pneumatic control valve that varies the boiler water flow rate in proportion to the steaming rate and water level signal. This new system has two benefits: (1) the more consistent flow of "cool" water to the boiler eliminates shocking effects, and (2) there is no water hammering on the pumps from cycling on and off. The new system also has added controls and a water level indicator to the main control room panel so the operator can see the condition of the boiler water level. To improve steam quality, a steam separator has been added. In addition, the cross connection to another steam line has been completed.

The water softener was originally specified at 11 gal/min with a 48-hr recharge cycle. This has since been changed to 25-gal/min capacity with a 24-hr recharge cycle. In practice, the softener is recharged every 48 hr. The chemical feed system was originally connected to tap water rather than softened water. It is now connected to the hot water from the DA tank for sulfite and to the cold, softened water for phosphates. One duplex pump unit is used. The unit has one motor with two pumps, each having separate flow-rate controls. The motor/pump combination is alternated weekly.

5.7.3 General Description - NAS Jacksonville

Each steam generator is a water-tube boiler manufactured by Abco Industries, Inc. The boiler is a horizontal unit positioned above the incinerator. The boilers are designed to produce saturated steam at 125 psig with a design rating of 150 psig. The nameplate steam production rate is 6280 lb/hr. The fire side of the boiler is designed to receive 17,000 lb/hr of flue gas at 1800°F. There are 264 tubes 2 1/2 in. in diameter with a 0.105-in. wall thickness and having an average length of 7 ft. This provides 968 ft^2 of heating surface. There is a 3/4-in. space between the rows, and there are three rows of tubes along each side. The boiler is designed to cool the flue gas to 500°F. The specifications called for the provision of full access to all fire side surfaces for inspection, cleaning, and repair and heat resisting observation ports to provide full observation of combustion conditions. The boiler has a mud drum and a steam drum with risers and downcomers. A manway is located at each end of these two drums.

There are three inspection doors and three observation ports for each boiler. Each boiler has a proportional pressure controller, boiler blowdown valves, primary and backup low water cutoff, feedwater regulator, and safety relief valves. Two rotary soot blowers manufactured by Copes-Vulcan were provided for automatic steam cleaning of the tubes. These soot blowers were driven by a 1/8-hp electric motor.

5.7.4 Auxiliaries - NAS Jacksonville

5.7.4.1 General Description--

There are two identical boiler feedwater pumps manufactured by the Demming Division of the Crane Company. They are vertical, in-line, centrifugal pumps with a design operating condition of 45 gal/min at a 375-ft head. Each of these single-stage pumps is driven by separate 20-hp electric motors. They are located on the roof above the restrooms in the parts storage area.

The deaerator was manufactured by the Chicago Heater Company. It is a horizontal spray type with integral storage. At overflow, it has a storage capacity of 479 gal. Its design pressure is 50 psig to full vacuum, and its operating pressure ranges from 2 psig to 15 psig. Its capacity is 20,000 lb/hr and its overall dimensions are 4 ft in diameter × 7 ft 4 in. in length with a 1/4-in. wall thickness. It is located on the third-level balcony above the office.

There are two identical makeup water pumps manufactured by Lockwood Pumps and supplied by Southern Plumbing Inc. The centrifugal pumps are each driven by a 1 1/2-hp electric motor and are capable of meeting the design conditions of 35 gal/min each at 100 ft of head. The pumps are located in an outside pit between the HRI building and Power Plant No. 2.

The blowdown tank was manufactured by Richmond Engineering Co. Inc. and supplied by Southern Plumbing Inc. The overall tank dimensions are 96 in. high × 30 in. in diameter with a 3/8-in. head and shell thickness. The tank is positioned next to the boiler feedwater pumps on the roof of the restrooms.

Its design pressure is 150 psig, and it was tested at 225 psig. Treated boiler water is supplied to the makeup water pumps by the system utilized in the adjacent Power Plant No. 2. There are no specifications for water treatment or steam quality.

5.7.4.2 Operation and Maintenance--

Steam is generated by passing the flue gases from the incinerator through the boiler gas passages where the heat of the gas is transferred to the water in the tubes. The gases are pulled through the boiler by the ID fan after the dump stack damper is closed. The gases then exit directly through the boiler stack. A steam pipe rising from each boiler steam drum connects into a steam pipe which transports steam a short distance north of the plant until it connects into the existing NAS steam system. A small percentage of steam is directed to the deaerator inside the incinerator building.

One of the two boiler feed pumps (one pump is a standby) delivers boiler feedwater from the deaerator to any one or more of the three boilers. Blowdown from the steam drum and mud drum goes to the blowdown tank. A portion of the blowdown in the tank flashes to steam and then travels to the deaerator. The remaining blowdown water in the blowdown tank is discharged to a wastewater drain. One of the two makeup water pumps (one pump is a standby) delivers softened water to the deaerator. There are no provisions for testing boiler water chemistry or for chemical addition to individual boilers.

The steam drum has a continuous blowdown, and the mud drum has a manual valve for intermittent blowdown to remove solids from the water. The low water cutoff float control operates switches that turn on feedwater pumps, turn on low water alarm, and bypass the flue gas flow to the boiler. The original Copes-Vulcan feedwater regulators, piped to the top and bottom of the steam drum, created a water column such that, as the water level dropped, the regulator expanded due to an increase in heat. This expansion mechanically operated a feedwater valve which supplied more feedwater to the boiler. The boiler pressure controller, a mercury switch, tilts as the steam pressure rises or falls. The proportional controller regulates the dump stack damper and the boiler exit damper and thereby allows more or less heat to be supplied to the water as the steam pressure decreases or increases. The soot blower functions to remove ash from the fire side of the water tubes by sending steam through the rotating soot blower elements located in gas passes.

The original automatic feedwater regulators did not function properly. They were originally installed backward. After correct installation, they were not able to cope with the water surges that frequently occurred, requiring that someone manually adjust the water levels. The water level sight gauge was located on the opposite side of the boiler from the manual water supply valve. Both items were located overhead, out of reach or view of the operators. A stepladder was required to see them. Because of these problems, additional personnel had to be assigned to boiler operation for an increased manpower requirement. As a result, steam production was initially limited to the first shift, (i.e., only 8 hr/day) and later was completely eliminated from the operation schedule. The longest period of continuous steam production, 12 hours, occurred during an NCEL test.

The boiler access platform is very difficult to get to. It involves going down steep stairs, around the unit, between the support beams, and then up another set of steep stairs. Access was further complicated by the fact that the boilers are not protected from the environment. This was also a factor involved in not operating the boilers during the night shifts.

There is no access to the boiler large enough to allow a person to get inside (Figure 26). The three 18-in.-diameter access ports in the sidewalls provide a view of only the first tube row. There is no measurement of temperature across the boiler, so there is no measurement of the capability of the soot blowers. During a recent inspection of Boiler No. 2, the first bank of 11 tube rows were found to be fouled with very soft fly ash but with little or no slag (Figure 27). The last bank of 11 tube rows were clean of fly ash but covered with rust. The center bank of 21 tube rows were not visible. About 6 in. of soft fly ash was found on the floor of the boiler entrance duct, and the very first row of tubes was almost completely covered with adhering, but soft, fly ash. It is not known what operational time this fly ash accumulation represents.

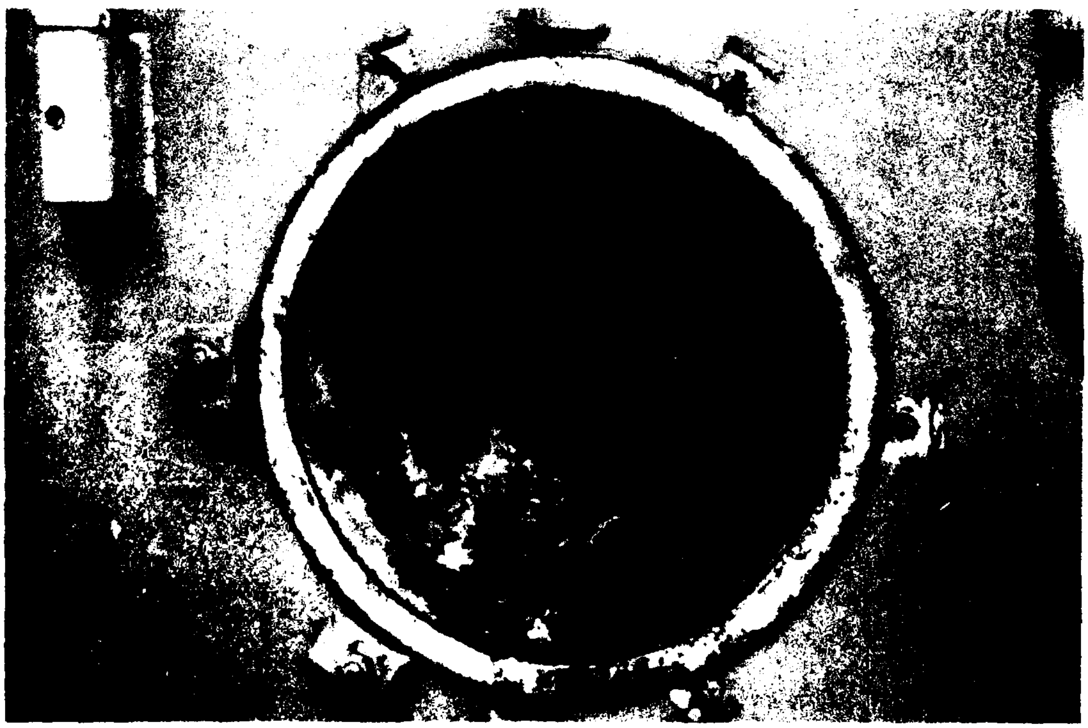

Figure 26. View through open access door of the boiler showing rust and fly ash buildup on boiler tubes and lack of maintenance access to clean tubes, NAS Jacksonville.

Figure 27. View from transition duct into boiler showing fly ash buildup in the tubes (A) and fly ash buildup in the duct (B).

There are manholes provided on the mud and steam drums. Maintenance personnel tried to enter and clean the water side of the tubes but were not successful, due to the lack of space. The area inside is too small to allow a person to work inside. Boiler No. 3 was described by the operators as being in the same condition as Boiler No. 2 at the time of complete plant shutdown.

5.7.4.3 Modifications--

The feedwater regulator was replaced with a Bailey Pneumatic Control System in May 1983. There is no measure of how it functioned because it was never used.

5.8 BREECHING AND INDUCED-DRAFT SYSTEM - NS MAYPORT AND NAS JACKSONVILLE

5.8.1 General Description - NS Mayport

Flue gases exiting the multiple cyclone dust collector next pass through an insulated steel breeching to the ID fan. This fan provides the draft needed to overcome the flow resistance of the dust collector, waste heat boiler, and the various interconnecting breechings and to maintain a negative pressure in the primary furnace. The frame holding the fan and motor is mounted on six isolation springs. A foundation pad was poured separate from the building and other equipment. The motor was mounted down and away from the fan, requiring a very long belt-drive system. The fan has two dampers, a fan discharge and a barometric inlet damper, both automatically modulated.

5.8.2 Operation and Maintenance - NS Mayport

The outlet damper of the ID fan is controlled by an amperage sensor on the motor current. The outlet damper is closed if the amperage increases beyond 80 amps. The atmospheric inlet damper is controlled by a pressure sensor in the first combustion chamber. The damper closes as the primary chamber draft increases towards positive. There are no interconnections between the two damper control systems. The atmospheric damper has been found to lag behind the chamber pressure changes. Positive pressures occur during periods of high gas release because the outlet damper can close due to high amperage. The controls on the ID fan are designed to allow a small range of operating current for the motor, not to provide precise chamber pressure control. The motor has been rewound once, and the fan bearings were replaced once. The drive belts are replaced yearly as part of the PM program. The belts are checked weekly, and the fan rotor is cleaned. Linkage and bearings are lubricated weekly.

5.8.3 Modifications - NS Mayport

The ID fan is thought to have been incorrectly mounted. A vibration problem, due to incorrect mounting, may have been the cause of the motor and fan bearing problems. Two of the six legs were mounted to the building foundation (rigid) while the other four were mounted on a separate pad (Figure 28). The vibration springs were worn or broken. New stiffer springs have been added while leaving the mounting configuration unchanged. No problems have occurred since this action.

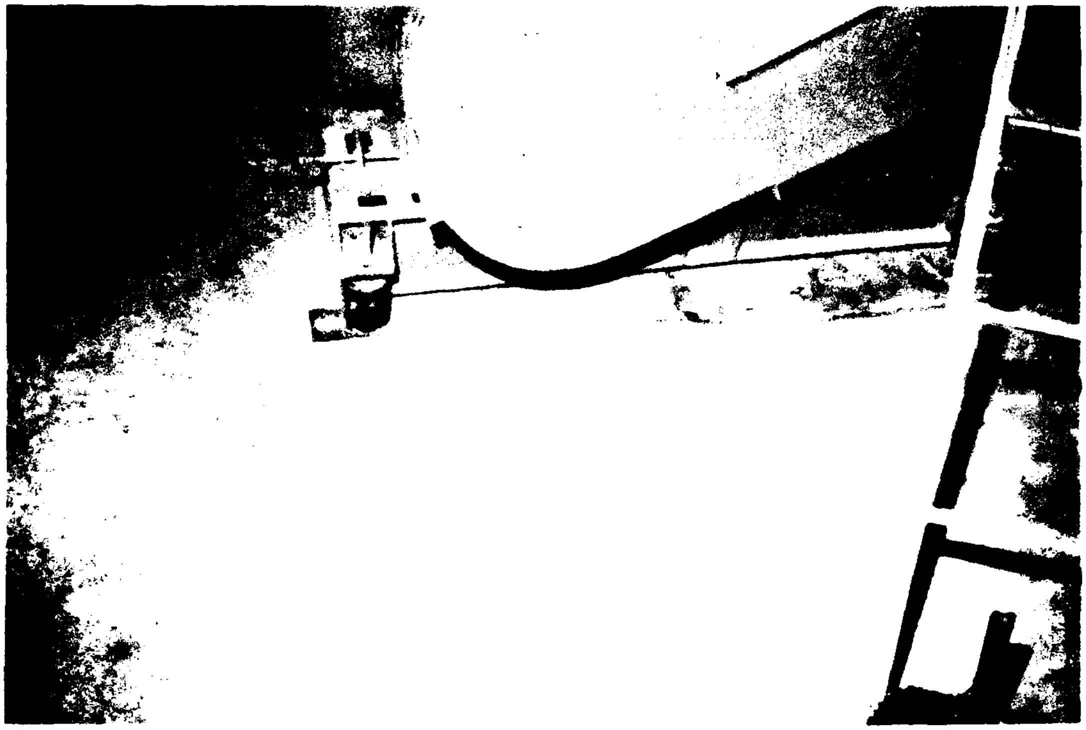

Figure 28. View of ID fan mounting showing isolation springs located off the isolated concrete pad, NS Mayport.

The motor is connected to the ID fan by a very long belt. This belt must be replaced annually at a cost of $500. Shorter belts, such as the one used on the forced-draft fan, only cost $125. The motor could be moved closer to the fan to reduce some of the cost associated with belt replacement.

5.8.4 Description - NAS Jacksonville

The ID fan and 30-hp motor are located on the boiler platform at the exit of each boiler. The fan is belt driven. A barometric inlet damper provides air to balance the mass flow through the fan. There is no outlet damper nor are there any automatic controls on the fan connected to the combustion chambers or boiler.

5.8.5 Operation and Maintenance - NAS Jacksonville

The only reported maintenance problems with the ID fan was an apparent imbalance on the final attempted start-up in May 1983, which was never corrected. The counterweight in the barometric damper was removed to increase the amount of air entering the damper and to decrease the negative draft in the combustion chambers. The damper was observed to open fully during boiler operation.

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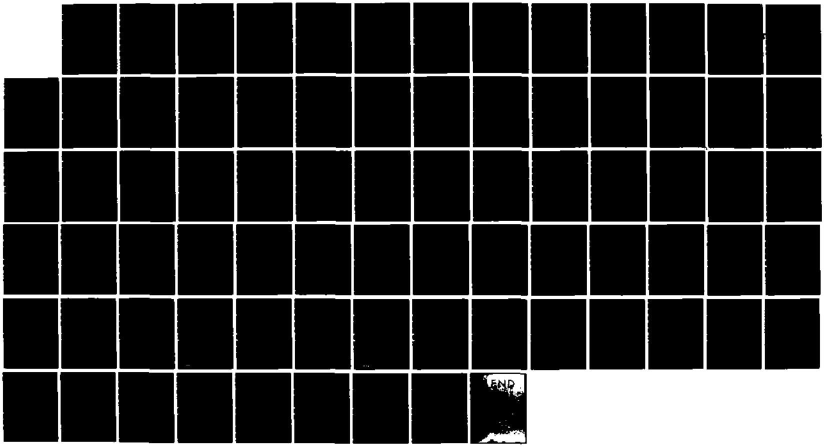

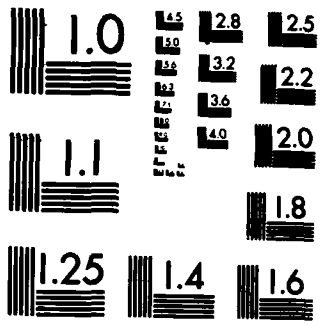
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5.9 AIR POLLUTION CONTROL SYSTEM - NS MAYPORT AND NAS JACKSONVILLE

5.9.1 General Description - NS Mayport

The furnace gases, having been cooled to approximately 500°F in passing through the waste heat boiler, flow through a multiple cyclone dust collector for the removal of fine dust (down to 10 microns in diameter) particles. The dust collector comprises a battery of 40 individual collector elements arranged for parallel flow so that one-fortieth of the total gas flow passes through each collector. The dust is discharged through a rotary air lock into an ash container.

5.9.2 Operation and Maintenance - NS Mayport

Approximately one-half of an 8-yd^3 container of fly ash is collected weekly. During start-up there were some problems with fly ash sticking in the hopper. Although the manufacturer recommended a hopper rapper, one was never installed. Some fly ash still does stick, but it does not cause any problems. In general, the air pollution control system is a very low maintenance item and is capable of achieving emissions control requirements. Preventive maintenance includes weekly cleaning and lubrication of the discharge valve on the ash hopper. Quarterly, the units are opened and cleaned out.

5.9.3 General Description - NAS Jacksonville

The design of this system is such that pollution control equipment was not deemed necessary. The starved-air operation of the primary chamber with a secondary chamber afterburner was intended to limit bed agitation and particle entrainment and provide complete combustion of gases and entrained particles. The incinerators were tested and passed air emissions regulations.

5.10 RESIDUE REMOVAL SYSTEM - NS MAYPORT AND NAS JACKSONVILLE

5.10.1 General Description - NS Mayport

The burned-out residue and noncombustible materials drop off the end of the grate into a large tank of water which serves to quench the residue and to provide an air seal. A continuous drag conveyor, powered by a 7.5-hp motor, collects the residue at the bottom of the tank and moves it up an elevated incline to the unloading point. The residue then drops into an open-top container. The drag chain was manufactured by Beaumont-Birch. The design employs two extra drive shafts and about 20 ft of extra chain to provide slack takeup or chain adjustment.

5.10.2 Operation and Maintenance - NS Mayport

During early operation, the drag chain was often jammed by clinkers, pipes, and other large unburned items. Since the discharge from the residue drop chute passes through the return pass of the drag chain and falls directly on top of the rear drive shaft, these large unburned items would get stuck in the rear sprocket area. Such jams caused the chain to jump off the sprocket and the shear pins to break. Items would also get wedged behind the

drag bars as they were dropped through the return pass of the drag chain. The drag bars would then carry these items to the back of the tank where they would then wedge. The present increased care in waste sorting has virtually eliminated the drag chain problems.

The drive motor that controls the speed of the drag chain has a gear box with 12 settings. It is normally run at the lowest setting, which is reported still to be too fast. The motor is connected to the gear box with belts which slip at high torque (which can occur even at low speed settings). There is no reversing mechanism, so the motor must be rewired to go backwards to help clear the jammed conveyor.

The chain link connector pins have not been changed or rotated since start-up. As a result, they are heavily worn on one side and must all be replaced. Annual pin rotation would even out the pin wear and yield a longer useful life. Preventive maintenance involves weekly inspection and tank cleaning and annual inspection of the drive system.

There are two wear plates on the quench tank under the drag bars. However, the quench tank has worn severely since there are no wear plates on the tank under the chain. The water used in the quench tank is untreated and has a high $CaCO_3$ concentration. The carbonate deposits build up in the floor drain, requiring it to be rodded out monthly. The contractor has added baffles and screens to the tank drain to reduce solids carry-over and to reduce the drain pluggage to some degree.

Eleven to 20 tons of residue are generated daily. It is hauled by the Navy Public Works Department for disposal on the station. It takes approximately 1 hr to dump the ash container. Since there is only one ash container, the ash conveyor must be stopped for the 1-hr dump cycle. During this time, ash which builds up on top of the conveyor becomes a source of conveyor jams. To alleviate this, the incinerator feed rate is reduced until the ash container is returned.

No reinforcement or special structures were originally provided for the ash container floor area. As a result, the tipping and sliding action of the container, when it is removed and replaced, has greatly worn the original floor. The operations contractor has had to emplace new concrete.

5.10.3 General Description - NAS Jacksonville

A single drag chain conveyor serves all three incinerators. The wet residue conveyor is a Transcon Model No. 458 drag chain. The 24-in.-wide by 77-ft-long steel belt travels horizontally for 46 1/2 ft in a water trough quench tank. It rises at a 35-degree angle to 7 ft above the ground level at which point it dumps the residue into an open-type, roll-off container. The chain is driven by a 3-hp Delco electric motor with a Falk worm gear speed reducer and V-belt drive. The tail shaft assemblies were originally provided below water with the conveyor belt assembly. The metal water trough is housed in a below-grade concrete pit. A sump pump is provided to drain the pit.

5.10.4 Operation and Maintenance - NAS Jacksonville

Residue is discharged from the incinerators through the action of the internal rams. The drag conveyor then moves the residue from the common quench tank up the incline to drain off some water, then finally dumps it into the bin. The bin is periodically removed for landfill disposal of the residue. During this time period the conveyor is not run. The drag chain returns beneath the residue drag chute under a false bottom of the quench tank.

The conveyor system was frequently jammed by a variety of materials ranging from small bolts to slag to unburned pieces of wood. When jams occurred, the incinerator feeding stopped because repairs to the conveyor usually required a lot of time to complete. This caused the temperature to go out of control which in turn led to enhanced slag buildup inside the combustion chamber. The jamming caused breakage of the chain links or loss of the motor drive shear pin. The rear sprocket of the conveyor was submerged, and the abrasive grit caused the brass bearings to wear out within the first year.

This conveyor is the same type used for industrial systems wherein the waste is generally more uniform and easier to handle. The chain was too weak for the type of material burned in this system. It wore and stretched very easily, requiring replacement of many feet of chain.

The conveyor tank is made from a light gauge metal and is showing signs of heavy wear and rust. The drag chains did have 1/8-in. wear plates under them, but the drags did not. Location of supports near the discharge end of the chain and the low height of discharge required a low-profile, roll-off container which had to be moved several times to fill completely. No concrete pad was provided under the container. For the period from June to November 1982, it was common that only one weight per week for the residue removed from the facility appeared on the operational records. This average weight was 0.14 ton/ton of waste incinerted.

5.10.5 Modifications - NAS Jacksonville

To alleviate the problems with the rear sprocket bearing, the sprocket was raised above the water level. A slide guide was put under the water.

5.11 INSTRUMENTATION AND CONTROLS - NS MAYPORT AND NAS JACKSONVILLE

5.11.1 General Description - NS Mayport

The system is operated from a control room located above the incinerator. A view of the entire tipping floor, incinerator, and boiler is possible from the control room, but it is impossible to fully view the pit. The instrumentation panel provides the operator with data concerning chamber temperatures, pressures, and combustion air damper positions; steam output and pressures; boiler water and quench tank level; and the amount of solid waste in the clamshell.

5.11.2 Operation and Maintenance - NS Mayport

The incinerator controls were originally wired from the equipment through a floor junction box into the control room. That situation was suspected of causing the alarm failures that ultimately led to costly boiler damage. In 1983, these controls were rewired through overhead conduit. Most of the other controls were originally wired through the concrete floor. Because such inaccessibility is not good, those wires too were eventually replaced, so that all control wiring has now been replaced.

In most respects, the main control panel was adequate. The equipment motors can be started from the control room only because the only disconnect switches are located at the motor. There are no burner controls on the main panel. The operator does not have any indication if the burner is off or on when the system is running in the automatic mode. As a result, the burners must be operated manually. The automatic control loops, which were designed to add more air as the temperature increased, are not used. The boiler level condition was originally monitored (by alarms) since there were no control mechanisms on the panel. A feedwater indicator and level control has recently been added. Operating data are recorded on continuous strip charts. It is recommended and would be preferred by the operators that the recording mechanism be changed to round daily charts. Such charts may be more effective and are certainly easier to read and evaluate. Preventive maintenance involves weekly inspection and monthly changing of charts. Inkers are usually replaced every month, and the drive belts are inspected. Semiannually, the printing mechanisms are lubricated. All gauges are only calibrated annually. The boiler drum level transmitter is checked and cleaned every 3 months and is only calibrated annually.

5.11.3 General Description - NAS Jacksonville

The control panel for each incinerator is located on the tipping floor in the loader/feed hopper area. The instrumentation panels provide the operator with data concerning chamber temperatures, pressures, and system failure alarms. Provision is made for automatic or manual modes of hydraulic component operation.

5.11.4 Operation and Maintenance - NAS Jacksonville

The location of the panels on the tipping floor left them highly susceptible to dust accumulation. The interiors of the control panels were laden with dust, which may have contributed to the automatic control failures. The following instrumentation was provided:

1. Feed cycle timer/counter; feeder ram timer (forward/back/jams)

2. Internal rams timer (forward/back/jams)

3. Residue conveyor (on/off)

4. ID fan, (on/off); combustion air fan (on/off)

5. Burners (on/off); waste oil (on/off)

6. Boiler feedwater pumps (on/off)

7. Boiler, low/high water alarms

8. Primary and secondary combustion chambers' temperature indicator/air flow and burner control high temperature alarms

9. Primary combustion chamber pressure indicator and limiter control (positive side only), secondary chamber pressure indicator

10. In-line steam (orifice plate) flow indicator and totalizer, steam header and steam line pressure (all located remote from two of the three control panel normal operating positions).

The following instrumentation was not provided but should have been:

1. A panel showing complete process flow diagram with status lights

2. Boiler outlet temperatures

3. Position indicator for the damper in the dump stack

4. Boiler water level

The lack of boiler inlet/outlet instrumentation prevented the detection of off-performance due to boiler tube fouling, effectiveness of the soot blowers, and amount of air infiltration down the dump stack.

Combustion chamber pressure is monitored in two locations, and the combustion air pressure is monitored in one location. The underfire air plenum is integrated with a pressure sensing switch to control the primary chamber burner purge cycle for the first hearth. The fan air must be on for the burner to ignite. At the exit of the primary chamber is a Photohelic brand pressure sensor that shuts the underfire air damper if positive pressure occurs in the primary chamber. The second pressure sensor, a Magnehelic brand, is at the exit of the secondary chamber. This serves only as an indicator to the operator and does not provide any control function.

SECTION 6.0

CONCLUSION WITH RESPECT TO PERFORMANCE OF MAJOR SUBSYSTEMS

6.1 FACILITY SITE AND WORK AREA ALLOCATIONS

Each facility was constructed on a site of approximately 80,000 sq ft. Based on evaluation of the NS Mayport HRI operation, this area is adequate for facilities with capacities up to 50 TPD. However, the HRI facility must have use of all 80,000 sq ft, whereas the NAS Jacksonville HRI had an existing electric substation, trees, and water drainage ditch utilizing valuable space. At NS Mayport, the area around the equipment was large enough, accessible, and sufficiently lit for maintenance. At NAS Jacksonville, the area and lighting was not adequate and accessibility was very difficult. Motors and controls were placed where they were difficult to reach when a problem occurred.

Neither maintenance area was adequate. More space is required for parts storage and a workshop. The NS Mayport site had a 30- × 29-ft maintenance and storage area, but it was being utilized by personnel for another function on the station, not the HRI. NAS Jacksonville had a total of 250 ft^2 for parts storage, but that was not sufficient to handle all the requirements of the RDF system.

6.2 RECEIVING AND TIPPING

The truck scale was not critical to the operation of either facility. The scales did not have sufficient capacity and length to weigh the residue removal truck at NS Mayport. The recorder at NAS Jacksonville was not located in the HRI control room and required extra labor to coordinate the weighing process.

Neither facility had sufficient floor space to receive and store the waste prior to processing. At NS Mayport, handling of the designed 50 TPD of waste required the use of floor space usually used for hand sorting. Therefore, the extent of hand sorting was reduced. At NAS Jacksonville, typically only 25 to 35 tons, or approximately 50 percent of the designed capacity, could be handled. NAS Jacksonville did not have sufficient push wall height and neither facility had sufficient stacking wall length.

6.3 PROCESSING

6.3.1 General

Both facilities were receiving solid waste containing large amounts of nonprocessible waste so that manual segregation was required. At least two persons per shift were required to sort the waste and move it onto the processing system or storage pit. If the nonprocessible material was not removed, it would cause jams in the RDF processing, waste storage, feeding, and residue removal systems. Hand sorting to the extent practiced was not originally intended or planned.

6.3.2 NS Mayport

The processing at NS Mayport required more manpower and floor space than originally planned. Floor space is very critical when the designed 50 TPD of waste is being received. The incinerator was to be able to handle items 4 ft in length and to burn wood mixed with the other waste. It cannot do this, and because these items are numerous, they severely complicate the operation.

6.3.3 NAS Jacksonville

The NAS Jacksonville processing line required two or more men to hand sort the waste before feeding it to the flail mill. The reliability of the processing line was very low because of the type of waste fed to the system, and the designed and as-constructed layout of the plant inhibited direct feeding of the incinerators. In partial defense of the system, the facility was receiving the "worst" waste on the station. Better waste, i.e., that with fewer large pallets, metal, bolts, etc., was taken directly to the landfill site in packer trucks. This occurred because the disposal costs of the roll-off container presented a better savings if they were taken to the HRI rather than the landfill. There was less cost incentive to process the packer truck waste.

6.4 STORAGE AND LOADING OF PROCESSED FUEL

6.4.1 NS Mayport

The NS Mayport pit and crane system is now functioning as designed. Earlier problems were caused because the lack of access resulted in limited maintenance on the crane. The pit provides enough room for the 50-TPD capacity. Since rebuilding, the ram and torque tube feeder are operating reliably. However, large and long items occasionally form holes in the compressed waste in the torque tube, which then permits some smoke and fire to enter the hopper.

6.4.2 NAS Jacksonville

The performance of of the traveling auger in the storage bin at NAS Jacksonville is not acceptable. The storage bin should not have been provided for use with primary shredded (flail mill) waste. The large stringers, rags, hose, etc., that were known to occur with that type of waste would easily wrap

around the auger and cause jamming. The bin would most likely work successfully with secondary shredded waste. The assumed bulk density of 6 to 9 lb/ft^3 for primary shredded and trommelled waste is too high, which led to inadequate storage capacity in the bin. This fact coupled with the use of narrow and steep rubber belt conveyors led to conveying problems. The ram loaders for the combustion chambers also were not reliable. Their location in a covered pit prevented proper housekeeping and maintenance. The volumetric method of filling the hopper with RDF to the same approximate depth did not permit uniform feeding of the combustor.

6.5 COMBUSTORS

6.5.1 NS Mayport

Although the combustor at NS Mayport is working, there are concerns that it is not working within the expectations of the original design, especially when near the 50-TPD design capacity. The design of temperature and pressure control loops were not adequate and require redesign. Control of the combustion process could be termed almost nonexistent. It appears that the grates and refractory will require rebuilding every 3 to 4 yr, which is a major cost. The primary chamber shows too much slagging, which indicates excessive temperatures, and the secondary chamber is collecting too much fly ash and slag. The slag and temperature is destroying the refractory. A large percentage of combustion is occurring on the grates and not on the hearth. The large amount of lofting fly ash from the grates is resulting in slag and dust problems throughout the system. The waste oil burner is in a poor location. The burner flame causes much fly ash carried over from the primary chamber to become viscous slag. This slag penetrates the refractory, and when the slag is cleaned off it pulls refractory with it.

6.5.2 NAS Jacksonville

The NAS Jacksonville combustors did not demonstrate the capability to reliably handle 1 TPH of processed RDF or direct fed waste. Design problems were evident in the air control and internal waste transfer systems. Infiltrating overfire air was not adequately controlled, resulting in high chamber temperature. The design of the internal rams left them susceptible to jamming and distortion. The operators' training did not adequately address the question of how to free a jam. Technical documentation was almost totally lacking in discussion or procedures for control of abnormal conditions, such as freeing jammed equipment.

The RDF systems could not produce sufficient processed waste to sustain long-term operation. Unreliability of the storage bin output and hand feeding of the hoppers more than likely resulted in underfeeding of the incinerator. This, coupled with the nonexistent essentially nonfunctional air control, resulted in low fuel-to-air ratios and concomitant high temperatures. The fact that the secondary chamber seldom received gas with a fuel value sufficient to raise the chamber temperature is a sign of low feed rates and lack of air control in the primary and secondary chambers (complete burnout).

6.6 DUMP STACK ASSEMBLY

The dump stacks at both facilities caused operational problems. The dump stack at NS Mayport required modifications because the original design allowed hot flue gases to escape when the cap was closed, and conversely, the cap would not open when required. At NAS Jacksonville, the design of the damper drive unit and the bearings were not adequate. The dampers did not function reliably. Concurrent problems were noted with the boiler exit damper.

6.7 BOILER AND AUXILIARIES

6.7.1 NS Mayport

The NS Mayport boiler was adequate for the needs of the HRI facility. The flue gas inlet temperature was usually low (1600°F), which tended to minimize sticky fly ash reaching the tubes. The capacities of the auxiliary equipment were adequate, but their operation and original piping was not correct. The system now runs satisfactorily.

6.7.2 NAS Jacksonville

The NAS Jacksonville boilers were not of a design that could be used on an HRI. The specifications required access for a man to clean the fire side and water side of the tubes. This specification was not met. The soot blowers apparently did not effectively clean the first bank of tubes since fly ash buildup was seen. There were no provisions for fly ash hoppers beneath the boilers and no way to remove the fly ash. It was observed to be slowly building up on the floor of the boiler (6 to 8 in. deep).

6.8 ID FAN AND STACK

6.8.1 NS Mayport

The NS Mayport fan was not designed with consideration given to long-term maintenance or part replacement, i.e., the long belt length on the ID fan. However, since the separate concrete pad was poured smaller than the fan frame, it is possible that the motor mounting was a change that occurred sometime after the concrete was poured. The control of the atmospheric air inlet damper of the fan by the primary chamber is the major concern and requires redesign. There are no problems with the stack.

6.8.2 NAS Jacksonville

The NAS Jacksonville ID fans have no control loops, they are either on or off. There are no electrically controlled inlet or outlet dampers as at Mayport. The counterweighted barometric inlet dampers did not adequately limit the magnitude of primary chamber draft during boiler operation, but did allow very high electrical energy consumption by the ID fans. In September of 1980, the ID fan power consumption by difference (on versus off) of about 40 kW each, exceeded the maximum of 37 kW recorded for the 200-hp flail mill.[19]

6.9 AIR EMISSIONS CONTROLS

The HRI facilities were permitted as carbonaceous fuel burners (same category as wood burners) which permitted higher particulate emissions than incinerator standards. The units would most likely not be permitted in other states (as incinerators) because their air tests were approximately 0.669 gr/DSCF at 12 percent CO_2 in NS Mayport and 0.107 gr/DSCF at 12 percent CO_2 in Jacksonville.[14,20]

The NS Mayport multi-clone was not an effective collector for the small diameter particulate being produced. The NAS Jacksonville starved-air incinerator was producing excessive particulate matter because the primary chamber was not operating in a starved-air mode.

6.10 RESIDUE REMOVAL

At NS Mayport, the inaccessibility of the rear drag chain sprocket and lack of a chain reversing switch complicates the clearing of jams caused by offensive items in the waste that were missed in the hand sorting processing. The NAS Jacksonville residue conveyor was not designed to handle unprocessed waste. The major problem when burning RDF was the chunks of slag. The shear pin and chain size were not adequate. More than one conveyor should have been provided, although experience with residue conveyors in small HRI facilities was not widely available at the time this facility was built. Large incinerators typically had two conveyors per unit or very heavy duty chains, drags, drives, and tanks.

6.11 INSTRUMENTATION AND CONTROLS

6.11.1 NS Mayport

The control system at NS Mayport gives the operator an indication of the status of the HRI equipment. The degree of control the operator has over the combustion process is questionable. The temperature control loop does not work, and the chamber pressure central system is complicated by the motor current control loop of the ID fan.

Communication between areas of the plant needs improvement. The operator cannot see the emissions from the stack and therefore cannot respond to emission problems by changing air flows.

6.11.2 NAS Jacksonville

The instrumentation and controls of the NAS Jacksonville incinerators were affected by dust and the outside environment. Dust produced by the RDF processing system accumulated on the local sensors and inside the control panels. The outside equipment and associated controls were fully exposed to the effects of the weather. The layout of the HRI control equipment, i.e., in pits and on the tipping floor rather than in a control room, also caused housekeeping and maintenance problems.

The automatic temperature and pressure control loops for the combustion chambers did not function adequately. The temperature control was too sensitive to the feed rate because of air infiltration. The units had to be operated above designed capacity before the controls would function. Pressure in the primary chamber was not controllable. The dump stack damper was to operate proportionally to the steam pressure, and this did not always work. The incinerators were most likely operated in an uncontrolled excess-air mode.

SECTION 7.0

LIFE CYCLE ECONOMICS

7.1 PERFORMANCE SUMMARY

The data presented in Tables 10, 11, and 12, are performance summary information for the HRIs at NS Mayport and NAS Jacksonville. The NS Mayport data are complete for a time period spanning October 1980 through August 1983. The data were obtained from an NCEL report.[21]

The data for NAS Jacksonville are not as complete as for NS Mayport. This is due primarily to the operational status of the Jacksonville facility. During its operational life, the facility would be considered in an extended shakedown phase with modifications occurring on a regular basis. This led to both sporadic operation and record keeping. The data presented for the time period August 1981 to March 1982 were obtained from a NAVFAC Southern Division report.[13] Complete data were not available to correlate or verify solid waste incinerated to any of the reported values. The data presented for June 1982 to May 1983 were obtained from an NCEL report.[22]

7.2 LIFE CYCLE COST ANALYSIS

The available performance data were used to develop the total operating cost and the total value of the energy generated by the HRI facilities over their 20-yr useful life period. A computer program developed by NCEL was utilized to complete the analysis.[23] The data input sheets are found in the appendix of this report. The summary sheets are presented in this section (Tables 13, 14, 15, and 16). The cost to produce steam and dispose solid waste are compared to the alternative costs of $11.40/MBtu of steam from fossil fuel and $52.82/ton landfill disposal costs.

7.2.1 NS Mayport

The as-operatored economic analysis results are presented in Table 13. The facility is burning solid waste at an average rate of 6534 tons per year (TPY) and is offsetting 4574 tons of waste per year that would alternatively go to a landfill site. A total of $\$4.00 \times 10^4$ MBtu/yr of usable steam energy can be produced. The discounted life cycle cost to burn solid waste is $74.97/ton and to produce a million Btu's of energy is $14.74. However, the HRI savings-to-investment ratio is only 0.97, resulting in a payback period greater than the projected life of the facility.

TABLE 10. AS-OPERATED PERFORMANCE SUMMARY, NS MAYPORT HRI FACILITY*

Activity	Oct/80-Mar/81	Apr/81-Sep/81	Oct/81-Mar/82	Apr/82-Sep/82	Oct/82-Mar/83	Apr/83 Aug/83	Total
6.1.1							
System Availability							
Burn Refuse (M2)	0.537	0.417	0.664	0.706	0.724	0.865	
Steam from Refuse & Oil (M1)	0.537	0.417	0.664	0.706	0.724	0.865	
6.1.2							
Refuse Processed (Tons) May	1904.92	1671.36	3231.36	3287.10	3307.84 1168.68[b]	2970.14	16372.72 [b](14233.56)
6.1.3							
Steam Produced (FFO, BOE/ton)	0.281	0.216	0.642	0.378	0.539	0.548	
6.1.4							
Operator Man years Utilized Manhour/MBtu Steam	0.366	0.462	0.313	0.387	0.322	0.420	

	Jul/82-Aug/83
6.1.6	
Utility Requirements	
1. Electrical kwh/hr	169.31
Electrical Btu	1.175×10^{10}
Cost @ 0.06/kwh	$10.16/hr
2. Diesel fuel-fed loader front-end loader	1403 gal
Btu	0.046×10^{10}
@ 1.22/gal	$1,712
3. Fuel oil gal	502
Fuel oil Btu	6.968×10^{7}
Fuel oil @ 1.12/gal	$562

Reference 21

TABLE 11. NS MAYPORT HRI FACILITY REPORTED MAINTENANCE COST 1983

Item	Total	Southern Technologies	Station
Crane	$ 8,565	$ 2,000	$ 6,565
Stoker	9,433	2,000	7,433
Odds	6,780	2,000	4,780
Loader ram	5,000	2,000	3,000
Front loader	6,790	6,790	--
Pumps	4,850	2,000	2,850
ID fan	1,750	1,750	
Total	$43,168	$18,540	$24,628

TABLE 12. NAS JACKSONVILLE SYSTEM PERFORMANCE SUMMARY

	Aug 81 to March 83*	June 82 to Nov 82†	Dec 82 to May 83†
System Availability			
Process/incinerate/steam		--	--
Process and incinerate		0.70	0.65
Incinerate only		0.86	0.83
Incinerate and steam		--	--
Process	.67		
Refuse Processed			
SW incinerated (tons)	N/A	1134	471
Steam Produced	N/A	0	0
Operator Man Years Utilize		N/A	N/A
kWh/ton	61		
kWh cost/ton	$ 2.73		
Fuel gal/ton incinerated	14.91		
Fuel cost/ton	$ 11.23		
Labor hour/ton	9.78		
Labor cost/ton	$107.54		

*Data supplied from South Division report using NCEL data. Unable to correlate tons received/incinerated to reported data.
†Reference 22

TABLE 13. NS MAYPORT ACTUAL HRI COST AND PERFORMANCE REPORT

Inflated per ton cost of disposing waste of the type generated at the site to the landfill	$ 52.82
Inflated per MBtu cost of the fossil fuel boiler to which the HRI is being compared	$ 11.49
Tons of trash burned annually by the HRI	6,534
MBtu's produced annually by the HRI (considering no downtime)	4.00E+04
Virgin petroleum fuel offset annually by the HRI in barrels of oil equivalent	4,074
Landfill space conserved annually by the HRI in tons	4,574
Cost of using a boiler to produce the annual no downtime quantity of steam produced by the HRI and landfilling all waste	$ 902,760
Inflated total capital cost of the HRI (includes equipment, support facilities and construction, and setup	$3,447,470
Uniform annual cost of the HRI (the cost of capital, modifications, labor, consumables, residue disposal downtime, and other costs spread over the economic life of the HRI)	$1,232,540
Annual no-downtime cost of the HRI (the total of no-downtime costs spread over the economic life of the HRI)	$1,229,940
Discounted life cycle cost of using a boiler to produce the life cycle no-downtime quantity of steam produced by the HRI and landfilling all waste (costs discounted to the point of initial funding)	$9,703,790
Discounted life cycle cost of the HRI	$9,797,880
Discounted life cycle cost of auxiliary fuels used by the HRI	$ 96,317
Discounted life cycle cost of noncombutible waste, ash, and scheduled downtime waste disposal	$ 611,567
Discounted life cycle cost of HRI downtime	$ 0
Discounted life cycle cost of the HRI per ton of waste fired	$ 74.97
Discounted life cycle savings of the HRI per ton of waste fired	$ 25.26
Discounted life cycle cost of the HRI per MBtu produced	$ 14.74
Discounted life cycle savings of the HRI per Mbtu produced	$ 4.97
Discounted life cycle savings of the HRI	$3,301,350
HRI savings to investment ratio	+0.97
Payback period in years (includes project lead time)	>Project Life

TABLE 14. NS MAYPORT POTENTIAL HRI COST AND PERFORMANCE REPORT

Inflated per ton cost of disposing waste of the type generated at the site to the landfill	$ 52.82
Inflated per MBtu cost of the fossil fuel boiler to which the HRI is being compared	$ 11.49
Tons of trash burned annually by the HRI	8,788
MBtu's produced annually by the HRI (considering no downtime)	5.60E+04
Virgin petroleum fuel offset annually by the HRI in barrels of oil equivalent	6,531
Landfill space conserved annually by the HRI in tons	6,152
Cost of using a boiler to produce the annual no downtime quantity of steam produced by the HRI and landfilling all waste	$ 1,263,860
Inflated total capital cost of the HRI (includes equipment, support facilities and construction, and setup	$ 3,447,470
Uniform annual cost of the HRI (the cost of capital, modifications, labor, consumables, residue disposal downtime, and other costs spread over the economic life of the HRI)	$ 1,258,050
Annual no-downtime cost of the HRI (the total of no-downtime costs spread over the economic life of the HRI)	$ 1,264,540
Discounted life cycle cost of using a boiler to produce the life cycle no-downtime quantity of steam produced by the HRI and landfilling all waste (costs discounted to the point of initial funding)	$13,585,300
Discounted life cycle cost of the HRI	$10,050,800
Discounted life cycle cost of auxiliary fuels used by the HRI	$ 123,548
Discounted life cycle cost of noncombutible waste, ash, and scheduled downtime waste disposal	$ 840,865
Discounted life cycle cost of HRI downtime	$ 0
Discounted life cycle cost of the HRI per ton of waste fired	$ 57.18
Discounted life cycle savings of the HRI per ton of waste fired	$ 39.43
Discounted life cycle cost of the HRI per MBtu produced	$ 11.31
Discounted life cycle savings of the HRI per Mbtu produced	$ 7.80
Discounted life cycle savings of the HRI	$ 6,929,920
HRI savings to investment ratio	+2.04
Payback period in years (includes project lead time)	10.0

TABLE 15. NAS JACKSONVILLE ACTUAL HRI COST AND PERFORMANCE REPORT

Inflated per ton cost of disposing waste of the type generated at the site to the landfill	$ 52.82
Inflated per MBtu cost of the fossil fuel boiler to which the HRI is being compared	$ 11.49
Tons of trash burned annually by the HRI	874
MBtu's produced annually by the HRI (considering no downtime)	0.00E+00
Virgin petroleum fuel offset annually by the HRI in barrels of oil equivalent	-1,483
Landfill space conserved annually by the HRI in tons	751
Cost of using a boiler to produce the annual no downtime quantity of steam produced by the HRI and landfilling all waste	$ 53,654
Inflated total capital cost of the HRI (includes equipment, support facilities and construction, and setup	$3,063,800
Uniform annual cost of the HRI (the cost of capital, modifications, labor, consumables, residue disposal downtime, and other costs spread over the economic life of the HRI)	$ 916,411
Annual no-downtime cost of the HRI (the total of no-downtime costs spread over the economic life of the HRI)	$ 919,372
Discounted life cycle cost of using a boiler to produce the life cycle no-downtime quantity of steam produced by the HRI and landfilling all waste (costs discounted to the point of initial funding)	$ 636,537
Discounted life cycle cost of the HRI	$7,139,110
Discounted life cycle cost of auxiliary fuels used by the HRI	$ 80,592
Discounted life cycle cost of noncombutible waste, ash, and scheduled downtime waste disposal	$ 110,402
Discounted life cycle cost of HRI downtime	$ 0
Discounted life cycle cost of the HRI per ton of waste fired	$ 408.60
Discounted life cycle savings of the HRI per ton of waste fired	$ 199.46-
Discounted life cycle cost of the HRI per MBtu produced	%1.70141E+38
Discounted life cycle savings of the HRI per Mbtu produced	%1.70141E+38
Discounted life cycle savings of the HRI	$3,485,020
HRI savings to investment ratio	-1.15
Payback period in years (includes project lead time)	>Project Life

TABLE 16. NAS JACKSONVILLE POTENTIAL HRI COST AND PERFORMANCE REPORT

Inflated per ton cost of disposing waste of the type generated at the site to the landfill	$ 52.82
Inflated per MBtu cost of the fossil fuel boiler to which the HRI is being compared	$ 11.49
Tons of trash burned annually by the HRI	9,359.00
MBtu's produced annually by the HRI (considering no downtime)	5.65E+04
Virgin petroleum fuel offset annually by the HRI in barrels of oil equivalent	8,420
Landfill space conserved annually by the HRI in tons	8,049
Cost of using a boiler to produce the annual no downtime quantity of steam produced by the HRI and landfilling all waste	$ 1,281,150
Inflated total capital cost of the HRI (includes equipment, support facilities and construction, and setup	$ 3,063,800
Uniform annual cost of the HRI (the cost of capital, modifications, labor, consumables, residue disposal downtime, and other costs spread over the economic life of the HRI)	$ 1,106,140
Annual no-downtime cost of the HRI (the total of no-downtime costs spread over the economic life of the HRI)	$ 1,069,270
Discounted life cycle cost of using a boiler to produce the life cycle *no-downtime* quantity of steam produced by the HRI and landfilling all waste (costs discounted to the point of initial funding)	$15,199,100
Discounted life cycle cost of the HRI	$ 9,272,750
Discounted life cycle cost of auxiliary fuels used by the HRI	$ 503,196
Discounted life cycle cost of noncombutible waste, ash, and scheduled downtime waste disposal	$ 1,278,330
Discounted life cycle cost of HRI downtime	$ 228,782
Discounted life cycle cost of the HRI per ton of waste fired	$ 49.54
Discounted life cycle savings of the HRI per ton of waste fired	$ 47.78
Discounted life cycle cost of the HRI per MBtu produced	$ 9.36
Discounted life cycle savings of the HRI per Mbtu produced	$ 9.03
Discounted life cycle savings of the HRI	$ 8,943,950
HRI savings to investment ratio	+2.96
Payback period in years (includes project lead time)	8.0

An expected optimum performance of the HRI with 18 percent downtime was developed and is presented in Table 14. The analysis indicated that the HRI could process 9518 TPY of solid waste and generate 6.03×10^4 MBtu/yr steam. The life cycle cost to produce steam is estimated at $9.96/MBtu and to process solid waste is $54.45/ton. The analysis indicates that a savings-to-cost ratio of 2.1:1 is possible and that the cost payback period is 9.9 yr.

The optimum analysis is from a hypothetical ideal perspective and does not represent actual conditions. Factors impacting the results are downtime, maintenance costs, and the availability of solid waste. Downtime could be more than the expected 18 percent/year due to the condition of the chamber refractory and the high percentage of nonprocessible waste. The maintenance cost in 1983 of $35,000 does not include costs for replacement of equipment that will routinely wear out after the first 3 to 4 yr of life. Future maintenance costs could be between $5 to $6/ton of refuse processed ($45,000 to $54,000/yr). The amount of solid waste fluctuates, and is usually from 25 to 45 TPD, depending on the number and type of ships in the harbor.

7.2.2 NAS Jacksonville

The as-operated economic analysis is presented in Table 15. The facility was never fully operational. Solid waste was processed at a rate of only 874 TPY, and no usable steam energy was produced. Only 751 TPY of solid waste was offset from alternative landfill disposal. The discounted life cycle cost to burn a ton of solid waste was $408.60. A similar cost of steam could not be computed. The payback period was greater than the projected facility life (Table 16).

This analysis is based on hypothetical data to indicate that the facility would have been economical if it had been operated as designed. Had the process equipment and incinerator worked effectively, a life cycle cost for steam generation of $9.50/MBtu and $54.37/ton of waste processed could have been attainable. Comments similar to those at NS Mayport relating to downtime and maintenance costs can be rejected for NAS Jacksonville. Solid waste availability is not a factor since more waste was available at the station. Operational staff typically was provided to operate the process line for only one shift. This assumes that the 8-hr throughput rate of the process line is equal to the 24-hr capacity of two incinerators. Such capacity is not possible.

SECTION 8.0

RECOMMENDATIONS FOR FUTURE SYSTEMS

8.1 OVERALL FACILITY

The facility size should be a minimum of 80,000 ft^2 for a 50-TPD plant and 120,000 ft^2 for a 100-TPD plant. The pre-engineered building should employ architectural features which will provide an appealing structure. Varied roof levels, different color and texture panels, and glass panels are possibilities. All these features are now standard available components of a pre-engineered metal building. A pleasing building will convert the "garbage plant" into an HRI facility in people's minds. The building should be large enough to house all the equipment. There should be adequate space within the building to promote proper equipment maintenance. A minimal maintenance area of 250 ft^2 and a nearby parts storage area of 250 ft^2 should be provided.

At least 3 ft and preferably 5 ft should be left open around each equipment component for maintenance access. These areas should be well lit to facilitate maintenance activities. Also, if the equipment is visible and well lit, it will tend to be kept clean and neat.

8.2 RECEIVING AND TIPPING

Truck scales are not required for daily operation of an HRI facility. They are useful only for data concerning the waste collection rate and residue or nonprocessible disposal. If a scale system is employed, the burden of its operation should be minimized by installing an automatic card reading and record keeping system. The scales should have a 50-ton capacity and be long enough to accomodate the roll-off residue container truck.

For 50- to 100-TPD HRI facilities, it is only necessary to design for one truck at a time to be able to back into the tipping floor area. At most, provisions for two trucks would be provided. At these capacities, the number of trucks arriving at any one time could not be many, and the time required for dumping is not significant.

Space should be provided to store or stack the waste prior to processing. One or two truck lanes should be provided leading up to a high concrete push wall. Wall heights of 8 to 15 ft should be used with the higher wall matched to a larger front loader.

8.3 PROCESSING

It is recommended that the HRI facility be considered as only one element of the waste disposal program. It should not handle that portion of the waste which contains oversized or nonprocessible material. The waste should be hauled directly to the landfill site. The feasibility study should determine which roll-off containers are to be diverted directly to the landfill. Additional containers should be placed to further help segregate the waste. Reduction in the delivery of problem waste to the HRI will improve the overall performance of the facility. Waste separation at the source should be enforced by daily inspection of containers until the old habits have been broken. Publicize the HRI and instill pride in its operation. This is easier if the previous recommendations on building appearance and design are followed.

8.4 STORAGE AND RETRIEVAL

The pit/crane system appears to be the best method to store and retrieve waste. It is recommended that the pit be preceded by a tipping floor. Trucks suspected of carrying nonprocessible items can dump their loads on the floor so the waste can be segregated as is currently done at NS Mayport. However, not all of the waste needs to be presorted. By experience, many trucks can be permitted to dump directly into the pit. This will minimize front loader and personnel time required for presorting. The crane grapple can be modified to contain an electromagnet for removal of steel. The crane should be operated from within the control room.

The multiple-load feed hopper of the general concept, but not of identical configuration as installed at NS Mayport, is recommended. Such a hopper provides automatic uniform feeding of the incinerator independent of the operator's action. This permits the operator to periodically divert his attention elsewhere without missing a load cycle. However, hydraulic cylinders with long stroke should be avoided. The hydraulic pump unit should be located in a well lit, readily accessible, and well maintained area.

8.5 COMBUSTORS

The use of an excess-air incinerator with a grate for moving the refuse through the chamber is recommended. Combustion air control is not as critical or as difficult as with a starved-air incinerator. Although the initial capital cost of the excess-air incinerator with grate is higher, the life cycle cost is lower and the availability and reliability are higher than the starved-air, refractory-hearth incinerator.

The refractory should be at least 9 in. thick and constructed of brick or castable material. The refractory should be air cooled by circulating combustion air between it and the outer shell. A minimum of 2-in.-high density mineral wool or equivalent should be used for backing the brick.

Underfire and overfire air should be provided at the grate level. Individual flow control for each air supply zone should be provided. Secondary overfire (cooling) air should be provided near the exit of the

primary combustion chamber and should be aimed away from the hearth, toward the chamber exit.

Temperature should be monitored at the chamber exit, and automatic control should be provided in the combustion chamber by first decreasing the over-grate air, then the under-grate air. If over-temperature still occurs, then the secondary overfire air should be increased.

A draft control loop should connect the ID fan outlet damper to the combustion chamber pressure sensor. The fan damper should modulate to keep the chamber pressure near the set point, with more draft being supplied as the chamber goes toward positive pressure. It is also possible to reduce the underfire air as the chamber pressure climbs toward positive. A barometric damper on the ID fan or recycling air loops is not required. Varying the current loading on the ID fan has not presented any problems in small HRI facilities evaluated in Europe.

The refuse should be agitated and moved through the chamber by an active grate system. Positive movement of all the residue lowers the possibility for slag buildup and improves waste burnout. The grate should be constructed of heat and abrasion resistant metal.

A small ignition burner should be provided to preheat and start the waste burning. If a burner for routinely combusting waste oil is also provided, it should be located in a refractory-lined duct as close as possible to the boiler. This will improve efficiency when firing only waste oil. Firing oil and solid waste at the same time is not recommended, and in fact, a separate waste oil boiler system is recommended. The thermal efficiencies would be higher, fewer fly ash furnace problems would exist, and the problem of balancing combustion demands of each fuel would be eliminated.

8.6 DUMP STACK ASSEMBLY

A dump stack is necessary if the plant is to burn waste but not produce energy. However, a dump stack is not recommended. Most of the Navy base HRI feasibility studies indicate that steam demand is available at all times. Based on the reliability data of these two HRI facilities, it is not the boiler related items that are causing downtime but rather the incinerator components. The dump stack is a source of air infiltration, and the cap or damper is a major maintenance item. To allow for fluctuation in steam demand, a steam condenser must be built if a dump stack is not. The boiler must have an emergency control system, and at least 1 and preferably 2 hr worth of emergency water supply.

8.7 BOILER AND AUXILIARIES

The boiler utilized at an HRI can be either a fire-tube or water-tube. A fire-tube boiler is less costly than a water-tube and can be effectively employed when saturated steam pressures of less than 250 psig are desired and when 5-day/wk operation is planned. The fire-tube boiler should be cleaned weekly. Adequate space at each end of the boiler for manual cleaning and a

soot system must be provided. A system such as a large industrial vacuum must be provided to collect the removed soot before it spreads through the plant.

A water-tube boiler can be used when higher saturated steam pressure or superheated steam is required and when 7-day/wk operation is planned. The water-tube boiler must be designed to permit a man to enter the boiler between the tube bundles, because sufficient room for manually cleaning the flue gas side of the tubes is needed. A compressed air soot blowing system must be provided. The use of a high pressure steam soot blower is not recommended because it can cause tube errosion. A steam-to-water or air-heat exchanger should be provided if steam production might exceed demand. This permits the boiler to be run at a constant production rate. Excess steam would be condensed and returned to the DA tank. This would improve the steam quality by eliminating boiler cycling. It would also simplify the HRI control system since flue gas diversion control would be no longer necessary and a dump stack would not be required.

Either type of boiler (flue or water-tube) should have the following auxiliaries:

1. Water softener equipment with at least a 48-hr cycle time between regeneration.

2. Boiler chemical mixing and metering system.

3. Boiler water test kits and wet sink.

4. Deaerator tank with 1-hr capacity for water feed at maximum boiler steaming rate.

5. Two boiler feedwater pumps with an emergency electric power system.

6. Boiler feedwater control valve and piping that permits pumps to run continuously, circulating water back to the DA tank if necessary, and a proportioning valve that supplies water to the boiler at the same rate as the steam demand (i.e., maintain a constant water level in the boiler).

7. Boiler blowdown piping should be designed so that periodic sampling and flow rate calibration are possible.

8. For supplying shore steam to Navy ships, a high efficiency steam separator should be provided where a high percentage of high quality condensate return is not assurable.

The following components are optional:

1. An auxiliary steam separator could be provided to improve steam quality. However, it should not be necessary for shore team demands if the boiler water treatment and boiler water level are adequately maintained.

2. Blowdown heat recovery can be supplied for the continuous blowdown system. However, since the flow rate of a continuous blowdown system is low due to the small size of the boiler, it is doubtful if the heat recovered would be significant. The blowdown water can also be utilized in the residue quench tank.

8.8 ID FAN AND STACK

The ID fan should be designed so that the fan rotor can be inspected and cleaned easily. The bearings and motor should be isolated from dust and water. The motor should be located close to the fan pulley to reduce the belt length. There is no need for a barometric inlet damper. A high quality, multiple-vane exit damper should be provided that opens if the electric power is lost.

A stack should be provided that is tall enough to provide some natural draft through the system should the electric power fail. The stack should have a ladder, platform, and ports for air emission testing. The stack should be constructed of concrete or steel and lined with refractory. The stack is very visible. It should be painted and maintained to improve the aesthetics of the HRI facility.

8.9 AIR EMISSION CONTROL

The requirement for an air emissions control system depends on the local or state regulations. The evaluated facilities were permitted as carbonaceous fuel furnaces which permitted higher emission levels than for waste incinerators. The excess-air grate and the starved-air incinerator will require an air pollution control device for reducing particulate emissions such as an electrostatic precipitator in order to comply with the requirement of 0.08 gr/DSCF, corrected to 12 percent CO_2. It is possible, during an emissions test, to fine tune the incinerator and burn selected material so as to reduce emissions during the test. In the case of a starved-air incinerator, it is even possible to approach or pass the 0.08 gr/DSCF limit without an APC system. However, normal (non-optimum) daily operation by the HRI staff and variations in the waste will cause excessive smoking and much higher emissions in the range of 0.15 to 0.2 gr/DSCF) unless APC equipment is used.

8.10 RESIDUE REMOVAL

In multiple unit HRI plants, separate residue removal system should be provided for each incinerator because of the high probability that a failure will occur in the residue removal equipment. A rack and pionion driven dredge system as employed by the Sigoure Freres facility in Millas, France, is recommended.[24] If used the drag chain should be of heavy construction simillar to the NS Mayport design. Wear plates should be installed under the chains and under the drags. The drive sprockets should be located out of the water, or the bearings should have a pressure lubrication system to prevent grit from entering. The rear sprocket should be located out from under the primary chamber so that no residue drops onto it and so that it is accessible from outside of the chamber. The returning drags should be located under

a false bottom inside the tank like NAS Jacksonville) or, if possible, up and over the residue drop chute as in the Ft. Eustis, Virginia, Consumat system.[25] The residue should not drop over the return drags as in the NS Mayport design since wire can wrap around them and other items can be carried to the rear of the tank. There should be at least 2 ft of vertical water space from the residue chute bottom to the flights of the drag conveyor. This is necessary to reduce the damage to the chute or jamming of the chain caused by long items or clinkers falling on top of a drag element. The opening of the residue drop chute from the combustion chamber should be as wide as the hearth area and over 2 ft in length to prevent bridging over the hole of long unburned items. The chute should be refractory lined down to within several inches of the water line and sealed to the bottom of the combustion chamber so that no air can infiltrate. The chute dimensions at the bottom should be equal to or greater than those at the top. The drag conveyor discharge residue container should be located on a concrete pad. Replaceable steel guides should be provided on which to slide the container.

8.11 INSTRUMENTATION AND CONTROLS

The controls should be located in a room partitioned off from the other functions of the plant. The room should have an air filtering system along with air conditioning/heating. The control room should have visibility of as much of the HRI equipment and receiving floor as possible. The control room should have an intercom system to the other areas. The control panel should dispay a process flow diagram having the following typical status indicator lights: motors (on/off), burners (on/off), dampers (open/closed), rams, (back/moving/forward), grate (stationary/moving), etc. An alarm horn or bell and indicator panel should be provided for chamber temperatures, moving equipment jams, and boiler water level. Auxiliary local hand controls should be provided at the residue conveyor to permit stopping and reversing (jiggling) of the drag chain conveyors. All motors should have local start/stop controls.

Temperature indicators and recorders should be provided on the control panel for the following locations: primary chamber, secondary chambers, boiler inlet/outlet, and air pollution control device outlet. Daily circular charts should be used since they are easier to use during review of the HRI operation than week- or month-long strip charts. Temperatures should be indicated locally for the following locations: feedwater, boiler makeup water, DA tank, and blowdown discharge.

Amperage or watt meters should be provided on the control panel for the ID fan, air pollution control device and any other large motor item. Pressure indicators should be provided in the control room and locally for the boiler, feed water, and steam drum, locally for the hydraulic systems, and pressure drops across the APC device and in the control room for the primary chamber draft. Air plenum pressure can vary due to the waste piled on top of the hearth and is useful only in indicator of the degree of plugging of the air injection ports.

The HRI should have an automatic cycle that feeds waste and modulates the air flow to maintain a set temperature. A manual override should also be

provided. Adjustable timers and temperature response controller should be provided and calibrated semiannually. Thermocouples should be inspected during each shutdown period and replaced quarterly. The ID fan outlet damper modulator (connected to the primary chamber pressure indicator/controller) should also be on an automatic control. The operator sets the pressure range desired and then the auto controls maintains that range.

The steam flow rate should be indicated by an in-line device, but the total flow should be calculated by a boiler feedwater meter. The flow rate should be recorded on a daily indicator chart on the control panel. The continuous boiler water blowdown meter values should be calibrated during the performance test and thereafter assumed to be constant during operation. Recalibration should be completed annually.

The operator should be required to complete an hourly operation status sheet similar to the NS Mayport daily operation log given in the appendix. On this sheet all temperatures, pressures, and meter readings should be recorded.

In addition, a detailed operation and maintenance should be provided containing operating and troubleshooting procedures, control/process interactions, and preventative and corrective maintenance procedures. A preventative maintenance schedule similar to the NS Mayport format listed in the appendix, should be used.

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APPENDIX

PERSONS INTERVIEWED ON SITE

NS MAYPORT

Roger Hamman, President, Southern Technologies, Inc.

Joe Masseo, Foreman, Southern Technologies, Inc.

NAS JACKSONVILLE

Bob LaVassuer, Director, Utilities

Steve Douglas, Director, Engineering

Jaime Stafford, Maintenance Mechanic

Bill Roche, Director, Environmental

Russ Robinson, Utilities Foreman

Dewey Napier, Boiler Plant Operator

John Larson, Boiler Plant Operator

NS MAYPORT

PREVENTIVE MAINTENANCE SCHEDULE

DAILY OPERATIONAL LOG

REFUSE INCINERATOR - BUILDING 1430
OTHER SCHEDULED MAINTENANCE REQUIREMENTS

CODE	EQUIPMENT	PM REQUIREMENTS
101	Primary Burner	<u>Weekly</u> Clean and lubricate air flow valve. ~~Use mineral oil SAE 30.~~ Km Rotate oil filters to clean. Clean Flame Scanner. SEMI <u>Bi-Annually</u> Remove and clean burner assembly. Inspect for broken or cracked parts. Check gas spud orifice for dirt build-up. Remove and inspect spark plug, replace if necessary. Check relays. Calibrate fuel and air flow. Remove and clean oil filter.
102	Primary Burner Controller	<u>Weekly</u> Inspect for oil leaks. Tighten loose bolts if necessary.
103	Secondary Burner	<u>Weekly</u> Clean and lubricate air flow valve. ~~Use mineral oil SAE 30.~~ Km Rotate oil filters to clean. Clean Flame Scanner. semi <u>~~Bi~~-Annually</u> Remove and clean burner assembly. Inspect for broken or cracked parts. Check gas spud orifice for dirt build-up. Remove and inspect spark plug, replace if necessary. Check relays. Calibrate fuel and air flow. Remove and clean oil filter.
104	Secondary Burner Controller	<u>Weekly</u> Inspect for oil leaks. Tighten loose bolts if necessary.
105	Heat Recovery Boiler	<u>Weekly</u> Open both boiler doors and inspect refractory. Inspect inlet and outlet tube sheets for leaks. Inspect tubes. Remove slag from inside boiler gas passage tubes. Inspect handhole and manhold gaskets for leakage. (Above maintenance should be done when boiler is cold.)

CODE	EQUIPMENT	PM REQUIREMENTS
	Heat Recovery Boiler (cont.)	<u>Quarterly</u> Check water side of boiler. Flush boiler to remove loose scale and sediment. Inspect heating surface for corrision, scaling, or pitting. Install new gaskets. Replace gauge glass and gaskets. Check try cocks for proper operation.
106	Crane System	<u>Monthly</u> Lubricate collection wheels with barium graphited cup grease NLGI #2. Check wheels and guide rollers on trolley. Check eye bolts on trolley. <u>Quarterly</u> Check wheels and collectors on bridge. Check collectors on trolley and geared drive. Check electric brakes on trolley. Check collectors on current conductor bar. <u>Bi-Annually</u> Replace trolley shoes. Check motors on bridge. Check electrical controls. Check head frames on trolley. Check motors on trolley. Check electrical connections. <u>Annually</u> Check hander rods, joints, fittings, end stop, and track on runways. Check end trucks, girder, and conductor bar and collectors. Check structural frame and load bars on trolley. Check track switches.
107	Hoist #1	<u>Monthly</u> Lubricate gear boxes, wet type brakes and cables. Check brake adjustment. Lubricate bearings with Lithium NLGI #2 grease.

CODE	EQUIPMENT	PM REQUIREMENTS
	Hoist #1 (cont.)	Quarterly Check motor operation and gearing. Semi Bi-Annually [illegible] ~~Lubricate motors~~, axle box, and shaft bearings. Check for loose bolts. Annually Change oil in gear boxes. Use Mineral Oil SAE 50.
108	Hoist #2	Monthly Lubricate gear boxes, wet type brakes and cables. Check brake adjustment. Lubricate bearings with Lithium NLGI #2 grease. Quarterly Check motor operation and gearing. Semi Bi-Annually [illegible] ~~Lubricate motors~~, axle box, and shaft bearings. Check for loose bolts. Annually Change oil in gear boxes. Use Mineral Oil SAE 50.
109	Hoist Motor #1	Weekly Check for loose, worn, or missing electrical connections. Monthly Lubricate motor bearings with Lithium NLGI #2 grease. Annually Change oil in gear boxes. Use Mineral Oil SAE 50.

CODE	EQUIPMENT	PM REQUIREMENTS
110	Hoist Motor #2	<u>Weekly</u> Check for loose, worn, or missing electrical connections. <u>Monthly</u> Lubricate motor bearings with Lithium NLGI #2 grease. <u>Annually</u> Change oil in gear boxes. Use Mineral Oil SAE 50.
111	Travel Motor #1	<u>Monthly</u> Lubricate motor bearings with Lithium NLGI #2 grease. Inspect all components of drive for wear, broken or loose parts, loose or frayed wiring. Lubricate wheel. <u>Annually</u> Change gear box oil. Use Mineral Oil SAE 50.
112	Travel Motor #2	<u>Monthly</u> Lubricate motor bearings with Lithium NLGI #2 grease. Inspect all components of drive for wear, broken or loose parts, loose or frayed wiring. Lubricate wheel. <u>Annually</u> Change gear box oil. Use Mineral Oil SAE 50.
113	Bucket	<u>Weekly</u> Visually inspect for damage. <u>Monthly</u> Check grab jaws and linkage.
114	Stoker Crate	<u>Weekly</u> Check grate and furnace conditions. Remove slag build-up. Check for obstructions in air passages. Replace grates as necessary.

CODE	EQUIPMENT	PM REQUIREMENTS
	Stoker Grate (cont.)	Monthly Check undercarriage for loose bolts. Tighten if necessary.
115	Ram Feeder	Weekly Clean and lubricate ram wheels and guides with Lithium NLGI #2 grease. Tighten loose mounting bolts.
116	Hopper Doors	Weekly Clean and lubricate bearings with Lithium NLGI #2 grease.
117	Ash Removal	Weekly Check motor for worn or loose electrical connections. Lubricate shear pin hub with Lithium NLGI #2 grease. Check oil level in chain casing. (Roller dips 1/2" into oil.) Use SAE 50 motor oil. Semi ~~Bi~~-Annually Inspect chain, flights, and gears for cracks or worn spots, replace if necessary. Annually Drain, flush, and refill chain casings. Use SAE 30 Mineral Oil.
118	Ash Conveyor Shaft Bearings	Weekly Grease all fittings using Lithium NLGI #2 grease. Inspect for damage. Semi ~~Bi~~-Annually Carefully examine bearings. Tighten loose bolts.
119	Weight Totalizing System Digital Indicator	Weekly Visually inspect cables and connections. Semi ~~Bi~~-Annually Calibrate input and output.

CODE	EQUIPMENT	PM REQUIREMENTS
120	Truck Weighing System	Weekly Wipe down unit.
121	Weight Indicator	Weekly Wipe dust off unit.
122	Emergency Generator Engine	Weekly Test run for 30 minutes. Check fuel and coolant systems. Check air filter and battery. Monthly Check drive belts. Semi ~~Bi~~-Annually Check hoses, radiator, battery, and charging alternator. Clean and lubricate control linkages with Mineral Oil SAE 30. Annually Change oil and filters. Use SAE 30 motor oil.
123	Emergency Generator	Quarterly Load test. Inspect and tighten electrical connections. Semi ~~Bi~~-Annually Clean and inspect unit. Annually Lubricate bearings with Lithium NLGI #2 grease.
124	Dust Collector	Weekly Clean and lubricate double flap valve cam drive. Use mineral oil SAE 50. Check quick disconnector. Quarterly Open inspection doors and clean out unit. Semi ~~Bi~~-Annually Lubricate motor with mineral oil SAE 50.

CODE	EQUIPMENT	PM REQUIREMENTS
125	Telemotive Radio Controlled Transmitter	<u>Weekly</u> Visually inspect for physical damage.
126	I.D. Fan Current Recorder and Controller	<u>Monthly</u> Replace chart and inker or as needed. semi <u>~~Bi~~-Annually</u> Inspect printing mechanism and belts. Lubricate printing mechanism carriage shaft.
127	Steam Flow Recorder	<u>Monthly</u> Replace chart and inker or as needed. semi <u>~~Bi~~-Annually</u> Inspect printing mechanism and belts. Lubricate printing mechanism carriage shaft.
128	Multi-Point Temperature Recorder	<u>Monthly</u> Replace chart and inker or as needed. semi <u>~~Bi~~-Annually</u> Inspect printing mechanism and belts. Lubricate printing mechanism carriage shaft.
129	Primary-Furnace Draft Recorder and Controller	<u>Monthly</u> Replace chart and inker or as needed. semi <u>~~Bi~~-Annually</u> Inspect printing mechanism and belts. Lubricate printing mechanism carriage shaft.
130	Primary Furnace Temperature Recorder/Controller	<u>Monthly</u> Replace chart and inker or as needed. semi <u>~~Bi~~-Annually</u> Inspect printing mechanism and belts. Lubricate printing mechanism carriage shaft.

CODE	EQUIPMENT	PM REQUIREMENTS
131	Hydraulic System Motor	<u>Weekly</u> Check for loose or missing connections or parts, noise and vibration. Wipe down motor. semi <u>~~Bi~~-Annually</u> Grease bearings by removing drain plug and pumping grease into fill hole. Run motor without drain plug to expell excess grease. Replace plug.
132	Feedwater Pump #1	<u>Weekly</u> Grease bearings and clean off pump. Use Lithium NLGI #2. Inspect for unusual noise, vibration, loose or missing connections or parts.
133	Feedwater Pump #2	<u>Weekly</u> Grease bearings and clean off pump. Use Lithium NLGI #2. Inspect for unusual noise, vibration, loose or missing parts.
134	Feedwater Pump Motor #1	semi <u>~~Bi~~-Annually</u> Grease bearings by removing drain plug and add grease through the fill hole with the motor running. Add grease until it comes out of drain hole. Continue running to expell excess grease. Replace drain plug.
135	Feedwater Pump Motor #2	semi <u>~~Bi~~-Annually</u> Grease bearings by removing drain plug and add grease through the fill hole with the motor running. Add grease until it comes out of drain hole. Continue running to expell excess grease. Replace drain plug.
136	Chemical Feedpump #1	<u>Weekly</u> Check for loose or missing connections or parts. Check fo· leakage, and oil level. semi <u>~~Bi~~-Annually</u> Change oil.

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CODE	EQUIPMENT	PM REQUIREMENTS
137	Chemical Feedpump #2	<u>Weekly</u> Check for loose or missing connections or parts. Check for leakage, and oil level. Semi <u>~~Bi~~-Annually</u> Change oil.
138	Feedwater Heater	<u>Weekly</u> Inspect for leaks and flush out.
139	Trolley Wheels	<u>Monthly</u> Lubricate bearings and guide rollers. Use Lithium NLGI #2 grease.
140	Chemical Tanks	<u>Monthly</u> Check for leaks. Clean tanks and lines. Clean off mixing motor. Check paddle condition.
141	Feedwater Meter #1	<u>Monthly</u> Check for leaks. Clean glass cover.
142	Feedwater Meter #2	<u>Monthly</u> Check for leaks. Clean glass cover.
143	I.D. Fan	<u>Weekly</u> Check belt tension and wear. Inspect and clean fan rotor and housing. Lubricate fan linkage and bearings. Use mineral oil SAE 50. Semi <u>~~Bi~~-Annually</u> Check fan blades and housing.
144	I.D. Fan Motor	<u>Weekly</u> Clean off motor. Check hold down bolts and proper alignment. Check electrical connections for worn, loose or missing parts. Semi <u>~~Bi~~-Annually</u> Lubricate bearings using Lithium NLGI #2 grease. Grease bearings.

CODE	EQUIPMENT	PM REQUIREMENTS
145	I.D. Damper Motor (Controller)	<u>Bi-Annually</u> Clean contacting surface with lint free cloth. Oil spur gears and swivel pins with lathe center oil. <u>Annually</u> Lube pivot point in receiver of each switch with one drop of instrument oil.
146	Stoker Fan	<u>Weekly</u> Clean out roof jets, hearth jets and bridge wall jets prior to lite off. Check dampers and intake screen. <u>Monthly</u> Lubricate bearings.
147	Stoker Fan Motor	<u>Weekly</u> Check electrical connections for worn, loose or missing parts. Check tension and wear belts. <u>Monthly</u> Clean off motor. <u>Annually</u> Grease bearings by removing drain plug and pumping grease into fill hole. Run motor without drain plug to discharge excess grease. Replace plug.
148	Stoker Fan Damper Controller	<u>Weekly</u> Clean Damper motor. Check linkage of modular control. SEMI <u>Bi-Annually</u> Clean contacting surface with lint free cloth. Oil spur gears and swivel pins with lathe center oil. <u>Annually</u> Lube pivot point and roller of each limit switch with one drop of instrument oil.
149	Hopper Air System	<u>Weekly</u> Check belt tension and wear.

CODE	EQUIPMENT	PM REQUIREMENTS
150	Hopper Air System Motor	<u>Weekly</u> Check for worn, loose or missing parts on electrical connections. <u>Monthly</u> Clean dust and dirt off unit. <u>Annually</u> Grease motor with drain plug out. Pump grease into fill hole. Run motor without drain plug to expell excess grease. Replace plug.
151	Hopper Air System Damper Control	<u>Weekly</u> Clean off unit. Semi <u>~~Bi~~-Annually</u> Clean contacting surface of slidewire with lint free cloth. Oil spur gears and swivel pins. <u>Annually</u> Lubricate pivot point and roller of each limit switch with one drop of instrument oil.
152	Pacemaker Motor (Ash Conveyor)	<u>Weekly</u> Check for worn, loose or missing parts on electrical connections. <u>Monthly</u> Clean dust and dirt off unit. <u>Annually</u> Grease motor with drain plug out. Pump grease into fill hole. Run motor without drain plug to expell excess grease. Replace plug.
153	Allispede Control	<u>Bi-Weekly</u> Clean off unit and lubricate bearings. Use Lithium NLGI #2 grease. Semi <u>~~Bi~~-Annually</u> Check belt alignment. Clean belt discs.

CODE	EQUIPMENT	PM REQUIREMENTS
154	Primary Combustion Chamber	<u>Weekly</u> Remove slag and clinkers. Check burner opening and furnace conditions. Check underfire and overfire air jets. Insure opening to secondary furnace is clear.
155	Secondary Combustion Chamber	<u>Weekly</u> Remove slag and clinkers. Check burner openings and furnace conditions. Insure opening to emergency stack is clear.
156	Forced Draft Fan Motor	<u>Weekly</u> Check for worn, loose or missing parts on electrical connections. Semi <u>~~Bi~~-Annually</u> Grease motor bearings by removing drain plug and pumping grease into fill hole. Run motor to expell excess grease. Replace plug.
157	Forced Draft Fan	<u>Weekly</u> Clean dirt off damper unit. Check belts for tension and wear. Clean out roof jets. Clean dampers and intake screen.
158	Main Stack	<u>Weekly</u> Remove slag and fly ash.
159	Emergency By-Pass Stack	<u>Weekly</u> Lubricate bearings on fail-safe damper with Lithium NLGI #2 grease. Check cable for wear. Remove slag and fly ash.
160	Waste Oil System	<u>Weekly</u> Clean and inspect waste oil strainer. Check motor for worn, loose or missing parts on electrical connections. Check system for leaks. <u>Monthly</u> Remove water from waste oil tanks.

CODE	EQUIPMENT	PM REQUIREMENTS
161	Diesel Oil System	Weekly Clean and inspect diesel oil strainer. Check system for leaks.
162	Gauges (Water and Air)	Annually Check for accuracy and replace as necessary.
~~163~~	~~Automatic Feedwater Control Mod.~~	
163	AIR COMPRESSOR	BI-WEEKLY CLEAN AIR FILTER MONTHLY CHECK AND ADJUST BELT TENSION AS REQUIRED. SEMI-ANNUAL CHANGE OIL AND CHECK SAFETY VALVE FOR PROPER OPERATION. ANNUAL INSPECT, CLEAN OR REPAIR VALVES.
164	AUTOMATIC FEEDWATER CONTROL SYSTEM.	QUARTERLY INSPECT NOZZLE TIP AND VANE AND CLEAN ORIFICE OF PNEUMATIC INDICATING CONTROLLER. CHECK ZERO AND ~~[illegible]~~ LINKAGE, CLEAN AND INSPECT NOZZLE TIP AND VANE OF DIFFERENTIAL PRESSURE TRANSMITTER. ANNUAL INSPECT, CLEAN AND CALIBRATE INDICATING CONTROLLER AND DIFFERENTIAL PRESSURE TRANSMITTER.

A-16

163	Air Compressor	Bi-Weekly	Remove and clean air filter.
		Monthly	Check and adjust belt tension as required.
		Semi-Annual	Change oil, check safety valve for proper operation.
		Annual	Inspect, clean or repair valves.
164	Drum Level Transmitter	Quarterly	Check zero and linkage. Clean nozzle tip and vane.
		Annual	Inspect, clean and calibrate.
165	Drum Level Controller	Quarterly	Inspect nozzle tip, vane and linkage. Clean orifice.
		Annual	Inspect, clean and calibrate.
166	Drum Level Control Valve	Annual	Inspect, clean and calibrate.

CARBONACEOUS STEAM PLANT / REFUSE INCINERATOR
BUILDING 430 246-5660

NAYPORT REFUSE INCINERATOR
MAYPORT FLORIDA

DATE:

DESCRIPTIVE DATA/TIME	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	TOTALS	REMARKS
1 BURNED (TONS)																										
2 REJECTED (TONS)																										
3 INCINERATED WET ASH (TONS)																										
4 FLY ASH (POUNDS)																										
5 BURNER #1 WASTE OIL METER READING																										
6 BURNER #1 VIRGIN OIL METER READING																										
7 BURNER #2 WASTE OIL METER READING																										
8 BURNER #2 VIRGIN OIL METER READING																										
9 #1 H_2O SOFTNER METER READING																										
10 #1 H_2O SOFTNER CONSUMPTION (GAL)																										
11 #2 H_2O SOFTNER METER READING																										
12 #2 H_2O SOFTNER CONSUMPTION (GAL)																										
13 AMOUNT OF SALT USED																										
14 AMOUNT OF PO_4 USED																										
15 AMOUNT OF SO_3 USED																										
16 FURNACE DRAFT (INCHES WC)																										
17 BOILER DRAFT IN (INCHES WC) [illegible]																										
18 BOILER DRAFT OUT (INCHES WC) .03																										
19 DUST COLLECTOR OUT (INCHES WC) .04																										
20 OVERFIRE AIR (INCHES WC) .05																										
21 HEARTH AIR (INCHES WC) .06																										
22 GRATE AIR (INCHES WC) .07																										
23 ID FAN RUNNING AMPS																										
24 FURNACE TEMP (F)																										
25 BOILER INLET TEMP (F)																										
26 BOILER OUTLET TEMP (F)																										
27 STEAM PRESSURE (PSI)																										
28 STEAM TEMP (F)																										
29 STEAM FLOW (METER READING)																										
30 STEAM FLOW METER READING (POUNDS)																										
31 FEEDWATER METER READING																										
32 FEEDWATER CONSUMPTION																										
33 FEEDWATER TEMPERATURE																										
34 STEAM TDS																										
35 STEAM PH																										
36 STEAM CONDUCTIVITY																										
37 STEAM SILICA																										
38 STEAM HARDNESS																										
39 BOILER WATER PO_4 PPM																										
40 BOILER WATER SO_3 PPM																										
41 BOILER WATER CAUSTICITY																										
42 BOILER WATER TDS																										
43 PERCENTAGE H_2O IN WET ASH																										
44 FEEDWATER PH																										
45																										
46																										
47																										
48																										
SHIFT OPERATORS SIGNATURE	1ST SHIFT								2ND SHIFT								3RD SHIFT									

SOUTHERN TECHNOLOGIES INC
LONGWOOD FLORIDA 32750 (305) 339-1882

NAS JACKSONVILLE

LISTING OF

RDF PROCESSING EQUIPMENT

The following table provides operating characteristics for the equipment contained in the functional flow diagram.

Table 2. Jacksonville HRI Functional Output Table.

Equipment	Block Number	Function	Operational Characteristics
Flail mill feed conveyor	6	Provides solid waste to flail mill	• 5 hp induction motor • 2.7-3.0 tph capacity (operating history)
Flail mill	7	Reduction of solid waste to 8- to 12-inch size	• 100 hp motors (2) • 10 tph capacity (design) • 2.7-3.0 tph capacity (operating history)
Vibrating conveyor	8	Absorbs shock from flail mill waste and delivers an even flow to the discharge conveyor	• 3 hp motor (430 rpm) • 4.5 lb/ft^3 at 5 tph (design) • 2.7-3.0 tph capacity (operating history)
Flail mill discharge conveyor	9	Carries flail mill and secondary shredder discharge materials to trommel screen	• 3 hp motor (1750 rpm) • 2.7-3.0 tph capacity (operating history) • 250 ft/min speed
Trommel screen	10	Removes glass, ceramic, and metallic particles not removed by the magnetic separator	• 15 hp motor • Screen rotates at 12 rpm • 2.8-3.0 tph capacity (operating history)
Storage bin feed conveyor	11	Transports waste from the trommel screen and cyclone to the storage bin	• 7-1/2 hp motor (1750 rpm) • 3 tph capacity (operating history)

Table 2. Jacksonville HRI Functional Output Table (Continued).

Equipment	Block Number	Function	Operational Characteristics
Storage bin	12	Acts as a surge bin to compensate in differences in front end processing train rate and incinerator burn rate	• 29 tons at 7 lbs/ft³ capacity in bin • 3/4 hp DC motor for traverse drive carriage
Screw augers	13	Provides for movement of waste in storage bin	• 25 hp AC motor for screw drive carriage
Storage bin discharge conveyor	14	Receives storage bin refuse and feeds incinerator conveyor #1	• 5 hp motor • 3 tph capacity (operating history)
Incinerator feed conveyor #1	15	Receives refuse from the storage bin discharge conveyor and feeds incinerator feed conveyor #2	• 5 hp motor (1750 rpm) • 3 tph capacity (operating history)
Incinerator feed conveyor #2	16	Receives refuse from the incinerator feed conveyor #1 and feeds incinerator #1 or incinerator feed conveyor #3	• 3 hp motor (1750 rpm) • 3 tph capacity (operating history)
Incinerator feed conveyor #3	17	Receives refuse from the incinerator feed conveyor #2 and feeds incinerators #2 and #3	• 2 hp motor (1750 rpm) • 3 tph capacity (operating history)
Incinerators	18	Consumes combustible solid waste	• 24 tons per-day burning capacity • 1.0 million Btu/hr capacity of primary burners • 1.54 million Btu/hr capacity of secondary main burner

Table 2. Jacksonville HRI Functional Output Table (Continued).

Equipment	Block Number	Function	Operational Characteristics
Incinerators (continued)	18		• 0.84 million Btu/hr capacity of secondary pilot burner • 3 cubic yards ram loader capacity • 10 hp motor drives loader
Boilers	19	Water-tube boiler	• 125 psig produced saturated steam pressure • 150 psig design pressure rating • 6,280 lb/hr max steam production • 6.28 million Btu/hr heat transferred to water side • 17,000 lb/hr of flue gas at 1800°F received on gas side • 500°F on water side • 1/8 hp motor for rotary soot blowers
ID fans	20	Pulls flue gas through the boiler and drives gas out the main stack	• 30 hp motor
Shredder feed conveyor	23	Transports objects to inlet of shredder	• 5 hp induction motor • 1 TPH capacity (operating history)
Industrial shredder	24	Reduces pallets, tires, or solid waste to 12-inch size	• 23 hp motors (2) • 60 rpm and 40 rpm blade velocity

Table 2. Jacksonville HRI Functional Output Table (Continued).

Equipment	Block Number	Function	Operational Characteristics
Industrial shredder (continued)	24		• 90-120 pallets/hr capacity • 350 car tires/hr capacity • 150 truck tires/hr capacity • 5 tph of solid waste capacity • 1 tph capacity (est) (operating history)
Shredder discharge conveyor	25	Transports waste from shredder to flail mill discharge conveyor	• 5 hp motor (1750 rpm)
Cyclone dust collector	26	Removes light fraction of the waste stream	• 1.5-inch WG pressure drop • 4600 cfm air volume
Dust bin	28	Collects light fraction of the waste stream	• 516 ft^3 volume
Blower	29	Exhausts air to atmosphere	• 4728 cfm air volume
Undersized discharge conveyor	30	Transports undersized particles from trommel screen to a waste bin	• 3/4 hp motor
Magnetic separator	32	Removes ferrous metals from waste stream	• 10 tph capacity • 4500 watt rectifier for power (460 volt, 3 phase 60 hertz input; 115 volt, dc output) • 5 hp motor
Ferrous metals discharge conveyor	33	Transports metals from magnetic separator to a waste bin	• 1/2 hp motor

Table 2. Jacksonville HRI Functional Output Table (Continued).

Equipment	Block Number	Function	Operational Characteristics
Air	35	Supplies air to the incinerators	• 7 1/2 hp motor • 6000 cfm capacity
Fuel and waste oil	36	Supplies fuel to the incinerators	• 7.5 gallons #2 fuel oil/ ton dry waste per day maximum • 1/3 hp motor for oil and air
Ash removal conveyor	37	Transports ash from incinerator to a waste bin	• 3 hp electric motor
Boiler feed pumps	41/ 42	Supply hot water from deaerator to boiler	• 45 gallons/min • 375 foot head • 20 hp electric motors (one each) • 125 psig water to boilers
Deaerator	43	Removes air from water, preheats water for boilers, and acts as a surge tank	• 92 ft^3 volume • 50 psig design pressure • 2-15 psig operating pressure • 20,000 lbs/hr capacity • 0.005 ml/liter oxygen maximum
Blowdown	46	Removes boiler water with high dissolved solids content and recovers the heat	• 2.6 ft^3 volume • 150 psig design pressure • 225 psig test pressure

LIFE CYCLE ECONOMICS

INPUT DATA ON COMPUTER SCREENS

```
                 DATA INPUT SCREENS FOR B:JAXHRI
                  ***  GENERAL INFORMATION  ***              SCREEN 01
               CURRENT MONTH:  5        CURRENT YEAR: 84

                    ***  NEAR-TERM FUTURE  ***
           NUMBER OF MONTHS BETWEEN ANALYSIS AND FUNDING: 24
            ANNUAL INFLATION RATES FOR THE FOLLOWING:
                   CAPITAL EXPENDITURES:  5.0
                                ENERGY: 10.0
                        LANDFILL COSTS: 10.0
                  ALL OTHER EXPENDITURES:  7.0

                   ***  PROJECT LEAD TIME  ***
            ARCHITECT/ENGINEER(%)             CAPITAL COSTS(%)
      YEAR 1     99.9                           25.0
      YEAR 2      0.1                           75.0      (NOTE: PERCENTAGES
      YEAR 3      0.0                            0.0       MUST ADD TO 100)
      YEAR 4      0.0                            0.0
      YEAR 5      0.0                            0.0
                 ***  PROJECT ECONOMIC LIFE  ***
ECONOMIC LIFE OF HRI IN YEARS: 20            DISCOUNT RATE (%): 10
DIFFERENTIAL INFLATION RATES (%) FOR ENERGY: 5      AND LANDFILL:  5

                 IS EVERYTHING CORRECT (Y/N)?
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```
         ***  CAPITAL COST FOR EQUIPMENT  ***           SCREEN 02
                            YEAR $:  0
       ITEM                COST          ITEM                    COST
    RECEIVING:                0    QUENCH TANK WATER TREATMENT:      0
    PROCESSING:               0    BOILER WATER TREATMENT:           0
    STORAGE:                  0    INSTRUMENTATION:                  0
    RETRIEVAL:                0    CONTROL SYSTEM:                   0
    INCINERATION:             0    FIRE AND EXPLOSION SUPPRESSION
    BOILER:                   0        EQUIPMENT:                    0
    ASH REMOVAL:              0    INITIAL SPARE PARTS INVENTORY:    0
    AIR POLLUTION:            0    OTHER:                            0
                                             TOTAL:                  0
          ***  CAPITAL COST FOR SUPPORT FACILITIES  ***
                            YEAR $:  0
                   ITEM                              COST
                BUILDING:                              0
                UTILITIES:                             0
                EARTHWORK AND ROAD CONSTRUCTION:       0
                OTHER:                                 0
                     TOTAL:                            0
         ***  CAPITAL COST FOR CONSTRUCTION AND SETUP  ***
                      YEAR$:  0       TOTAL:         0
                     IS EVERYTHING CORRECT (Y/N)?
```

*** TOTAL CAPITAL COST *** SCREEN 03

YEAR $: 77 TOTAL: 1983000

*** CAPITAL COST FOR EXPECTED MODIFICATIONS ***

YEAR $: 78

DESCRIPTION OF MODIFICATION	MODIFICATION COST	ECONOMIC LIFE YEAR
MOD 1	442971	1
MOD 2	75000	5
MOD 3	100000	10
MOD 4	100000	15
	0	0
	0	0
	0	0
	0	0
	0	0
	0	0

*** CAPITAL COST FOR ARCHITECT AND ENGINEER SERVICES ***

PERCENTAGE OF ALL CAPITAL COSTS IDENTIFIED ABOVE: 10.0

IS EVERYTHING CORRECT (Y/N)?

*** LABOR COSTS *** SCREEN 04

YEAR $: 83

OPERATION	NO DOWNTIME ANNUAL MANHOURS(MHR)	RATE($/HR)	TOTAL	ASSIGNED TO DOWNTIME(%)
SUPERVISORY	2080	14.40	0	50
SKILLED	12480	8.60	0	50
UNSKILLED	10400	7.50	0	50
TOTAL OPERATION LABOR COST:			0	

PREVENTIVE MAINTENANCE	ANNUAL MANHOURS(MHR)	RATE($/HR)	TOTAL
SUPERVISORY	0	0.00	0
SKILLED	0	0.00	0
UNSKILLED	0	0.00	0
TOTAL PREVENTIVE MAINTENANCE LABOR COST:			0

CORRECTIVE MAINTENANCE	MHR/CORRECT MAINT HR	RATE($/HR)	
SUPERVISORY	0.2	14.40	
SKILLED	0.4	8.60	
UNSKILLED	0.4	7.50	
TOTAL CORRECTIVE MAINTENANCE LABOR COST:			0

IS EVERYTHING CORRECT (Y/N)?

```
                      ***  COST OF CONSUMABLES  ***                SCREEN 05
                                YEAR $:   83
ELECTRICITY:         KWH/OPERATING HR:    147          $/KWH:  0.073
                         KWH/DOWNTIME HR (% OF KWH/OP HR):  20.0
                   KWH/SCHEDULED NON-OP HR (% OF KWH/OP HR):   0.0

AUXILIARY FUELS THAT OFFSET USE OF                VIRGIN PETROLEUM FUELS
  VIRGIN PETROLEUM FUELS
           GAL/TON    $/GAL      BTU/GAL          GAL/TON    $/GAL      BTU/GAL
LIQUID:     0.000     0.00          0             10.000     1.08      130000
       1000 CF/TON  $/1000 CF  BTU/1000 CF    1000 CF/TON  $/1000 CF  BTU/1000 CF
GAS:        0.00      0.00          0              0.00      0.00           0
           TON/TON    $/TON      BTU/TON          TON/TON    $/TON      BTU/TON
SOLID:      0.00      0.00          0              0.00      0.00           0
SOLID:      0.00      0.00          0              0.00      0.00           0

MAKEUP WATER:  GAL/TON:  800     $/1000 GAL:  1.00    OR ANNUAL TOTAL:     0
CHEMICALS:
   CHEMICAL    UNITS/1000 GAL MAKEUP WATER    $/UNIT    OR     ANNUAL TOTAL
                    0.00                       0.00                 0
                    0.00                       0.00                 0
                           TOTAL ANNUAL COST OF CHEMICALS: 10000
                     IS EVERYTHING CORRECT (Y/N)?
```

```
                     ***  OTHER COSTS  ***                 SCREEN 06
  ITEM               ANNUAL COST       YEAR $
REPAIR PARTS            50000            84
SEWER                       0             0
INSURANCE                   0             0
PEST/VERMIN CONTROL         0             0
RESIDUE DISPOSAL                  YEAR $: 83
  (ENTRIES MUST BE MADE FOR EACH OF THE FOLLOWING THREE GROUPS)
      TRANSPORTATION COST OF NON-BURNABLE WASTE ($/TON-MILE):   0.00
      NUMBER OF MILES TO NON-BURNABLE WASTE LANDFILL:             0
      TIPPING FEE AT NON-BURNABLE WASTE LANDFILL ($/TON):       0.00
   OR COST OF LANDFILL DISPOSAL OF NON-BURNABLE WASTE ($/TON): 40.00

      TRANSPORTATION COST OF ASH ($/TON-MILE):                  0.00
      NUMBER OF MILES TO ASH DISPOSAL LANDFILL:                   0
      TIPPING FEE AT ASH DISPOSAL LANDFILL ($/TON):             0.00
   OR COST OF LANDFILL DISPOSAL OF ASH ($/TON):                11.11

      TRANSPORTATION COST OF ALL WASTE GENERATED ($/TON-MILE):  0.00
      NUMBER OF MILES TO LANDFILL:                                0
      TIPPING FEE AT LANDFILL ($/TON):                          0.00
   OR COST OF LANDFILL DISPOSAL OF ALL WASTE ($/TON):          40.00
                   IS EVERYTHING CORRECT (Y/N)?
```

*** OTHER COSTS *** SCREEN 07

ITEM	ANNUAL COST	ECONOMIC LIFE YEAR	AND COST	TYPE COST (C,E,L, OR O)	YEAR $
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0

IS EVERYTHING CORRECT (Y/N)?

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                 ***   OPERATING DATA  ***                          SCREEN 08

TONS OF NON-BURNABLE WASTE/TON OF WASTE:                         0.140
ESTIMATE OF HRI COMBUSTION RATE (TONS/HOUR):                     1.65
HRI TURN-UP CAPABILITY (PERCENT ABOVE NORMAL FIRING RATE):       20.0
TONS OF ASH (BOTTOM OR FLY)/TON OF BURNED WASTE:                 0.14
$/MBTU OUTPUT OF FOSSIL FUEL BOILER AND YEAR $:                   8.70  83
THERMAL EFFICIENCY OF FOSSIL FUEL BOILER (%):                    80.0
HEATING VALUE OF BURNABLE WASTE (BTU/TON):                       11800000
HRI FURNACE TYPE (R=REFRACTORY, W=WATER WALL):                   R
THERMAL EFFICIENCY OF THE HRI (%):                               45.0
ESTIMATE OF HRI TOTAL ANNUAL DOWNTIME DUE TO FAILURE (%):        20
ESTIMATE OF HRI ANNUAL NUMBER OF FAILURES:                        35
ESTIMATE OF MAXIMUM HRI DOWNTIME (HOURS):                        120
TIME REQUIRED TO COMPLETE A DAYS DELIVERY (HOURS):                6
STORAGE SPACE AVAILABLE AT HRI (TONS):                            45
HRI OPERATING SCENARIO:
    1=BURN 2 SHIFTS, 5 DAYS   2=BURN CONTINUOUSLY, 5 DAYS        2
    3=BURN 2 SHIFTS, 7 DAYS   4=BURN CONTINUOUSLY, 7 DAYS
    5=BURN CONTINUOUSLY, 4 DAYS, FOLLOWING DAY 1 RECEIPT
HRI PLANNED ANNUAL OPERATING WEEKS:                              52

                 IS EVERYTHING CORRECT (Y/N)?
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HRI COST AND PERFORMANCE REPORT

INFLATED PER TON COST OF DISPOSING WASTE OF THE TYPE GENERATED AT THE SITE TO THE LANDFILL:	$52.82
INFLATED PER MBTU COST OF THE FOSSIL FUEL BOILER TO WHICH THE HRI IS BEING COMPARED:	$11.49
TONS OF TRASH BURNED ANNUALLY BY THE HRI:	9,359.
MBTUS PRODUCED ANNUALLY BY THE HRI (CONSIDERING NO DOWNTIME):	6.07E+04
VIRGIN PETROLEUM FUEL OFFSET ANNUALLY BY THE HRI IN BARRELS-OF-OIL-EQUIVALENT:	7,740.
LANDFILL SPACE CONSERVED ANNUALLY BY THE HRI IN TONS:	8,049.
COST OF USING A BOILER TO PRODUCE THE ANNUAL NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE:	$1,329,580.
INFLATED TOTAL CAPITAL COST OF THE HRI (INCLUDES EQUIPMENT, SUPPORT FACILITIES, AND CONSTRUCTION AND SETUP):	$3,063,800.
UNIFORM ANNUAL COST OF THE HRI (THE COST OF CAPITAL, MODIFICATIONS, LABOR, CONSUMABLES, RESIDUE DISPOSAL, DOWNTIME, AND OTHER COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI):	$1,170,2[illegible].
ANNUAL NO-DOWNTIME COST OF THE HRI (THE TOTAL OF NO-DOWNTIME COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI):	$1,146,350.
DISCOUNTED LIFE CYCLE COST OF USING A BOILER TO PRODUCE THE LIFE-CYCLE NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE (COSTS DISCOUNTED TO THE POINT OF INITIAL FUNDING):	$15,[illegible]3,700.
DISCOUNTED LIFE CYCLE COST OF THE HRI:	$10,177,[illegible]00.
DISCOUNTED LIFE CYCLE COST OF AUXILIARY FUELS USED BY THE HRI:	$1,677,320.
DISCOUNTED LIFE CYCLE COST OF NONCOMBUSTIBLE WASTE, ASH, AND SCHEDULED DOWNTIME WASTE DISPOSAL:	$1,278,330.
DISCOUNTED LIFE CYCLE COST OF HRI DOWNTIME:	$197,853.
DISCOUNTED LIFE CYCLE COST OF THE HRI PER TON OF WASTE FIRED:	$54.3[illegible]
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER TON OF WASTE FIRED:	$46.02
DISCOUNTED LIFE CYCLE COST OF THE HRI PER MBTU PRODUCED:	$9.50
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER MBTU PRODUCED:	$8.04
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI:	$8,613,660.
HRI SAVINGS-TO-INVESTMENT RATIO:	+2.85
PAYBACK PERIOD IN YEARS (INCLUDES PROJECT LEAD TIME):	8.3

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                    DATA INPUT SCREENS FOR B:MAYPHRI
                      ***  GENERAL INFORMATION  ***              SCREEN 01
                  CURRENT MONTH:  5          CURRENT YEAR: 84

                         ***  NEAR-TERM FUTURE  ***
              NUMBER OF MONTHS BETWEEN ANALYSIS AND FUNDING: 24
               ANNUAL INFLATION RATES FOR THE FOLLOWING:
                         CAPITAL EXPENDITURES:  5.0
                                      ENERGY: 10.0
                              LANDFILL COSTS: 10.0
                       ALL OTHER EXPENDITURES:  7.0

                        ***  PROJECT LEAD TIME  ***
               ARCHITECT/ENGINEER(%)          CAPITAL COSTS(%)
       YEAR 1       99.9                         25.0
       YEAR 2        0.1                         75.0         (NOTE: PERCENTAGES
       YEAR 3        0.0                          0.0          MUST ADD TO 100)
       YEAR 4        0.0                          0.0
       YEAR 5        0.0                          0.0
                       ***  PROJECT ECONOMIC LIFE  ***
 ECONOMIC LIFE OF HRI IN YEARS: 20              DISCOUNT RATE (%): 10
 DIFFERENTIAL INFLATION RATES (%) FOR ENERGY:  4          AND LANDFILL:  4

                       IS EVERYTHING CORRECT (Y/N)?
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      *** CAPITAL COST FOR EQUIPMENT ***                                SCREEN 02
                            YEAR $: 77
    ITEM                 COST        ITEM                              COST
 RECEIVING:                 0    QUENCH TANK WATER TREATMENT:             0
 PROCESSING:                0    BOILER WATER TREATMENT:                  0
 STORAGE:                   0    INSTRUMENTATION:                         0
 RETRIEVAL:                 0    CONTROL SYSTEM:                          0
 INCINERATION:              0    FIRE AND EXPLOSION SUPPRESSION
 BOILER:                    0         EQUIPMENT:                          0
 ASH REMOVAL:               0    INITIAL SPARE PARTS INVENTORY:           0
 AIR POLLUTION:             0    OTHER:                                   0
                                          TOTAL:                          0
            *** CAPITAL COST FOR SUPPORT FACILITIES ***
                            YEAR $:  0
                  ITEM                               COST
              BUILDING:                                 0
              UTILITIES:                                0
              EARTHWORK AND ROAD CONSTRUCTION:          0
              OTHER:                                    0
                    TOTAL:                              0
          *** CAPITAL COST FOR CONSTRUCTION AND SETUP ***
                      YEAR$:   0       TOTAL:       0
                    IS EVERYTHING CORRECT (Y/N)?
```

*** TOTAL CAPITAL COST *** SCREEN 03

YEAR $: 77 TOTAL: 2231329

*** CAPITAL COST FOR EXPECTED MODIFICATIONS ***

YEAR $: 78

DESCRIPTION OF MODIFICATION	MODIFICATION COST	ECONOMIC LIFE YEAR
MOD 1	56963	1
MOD 2	50000	5
MOD 3	100000	10
MOD 4	100000	15
	0	0
	0	0
	0	0
	0	0
	0	0
	0	0

*** CAPITAL COST FOR ARCHITECT AND ENGINEER SERVICES ***

PERCENTAGE OF ALL CAPITAL COSTS IDENTIFIED ABOVE: 10.0

IS EVERYTHING CORRECT (Y/N)?

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                        ***  LABOR COSTS  ***                     SCREEN 04
                             YEAR $:    83
                  NO DOWNTIME                                        ASSIGNED TO
 OPERATION        ANNUAL MANHOURS(MHR)   RATE($/HR)        TOTAL     DOWNTIME(%)
     SUPERVISORY             0              0.00              0            0
     SKILLED                 0              0.00              0            0
     UNSKILLED               0              0.00              0            0
                           TOTAL OPERATION LABOR COST:   367000

 PREVENTIVE MAINTENANCE     ANNUAL MANHOURS(MHR)   RATE($/HR)        TOTAL
            SUPERVISORY            0                 0.00              0
            SKILLED                0                 0.00              0
            UNSKILLED              0                 0.00              0
                        TOTAL PREVENTIVE MAINTENANCE LABOR COST:       0

 CORRECTIVE MAINTENANCE     MHR/CORRECT MAINT HR   RATE($/HR)
            SUPERVISORY        0.0                   0.00
            SKILLED            0.0                   0.00
            UNSKILLED          0.0                   0.00
                        TOTAL CORRECTIVE MAINTENANCE LABOR COST:       0


                         IS EVERYTHING CORRECT (Y/N)?
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```
                         ***  COST OF CONSUMABLES  ***                    SCREEN 05
                                YEAR $:    83
  ELECTRICITY:          KWH/OPERATING HR:    300          $/KWH:   0.073
                           KWH/DOWNTIME HR (% OF KWH/OP HR):   20.0
                    KWH/SCHEDULED NON-OP HR (% OF KWH/OP HR):    0.0

  AUXILIARY FUELS THAT OFFSET USE OF                 VIRGIN PETROLEUM FUELS
    VIRGIN PETROLEUM FUELS
             GAL/TON     $/GAL       BTU/GAL         GAL/TON     $/GAL       BTU/GAL
  LIQUID:     10.000      0.50       130000            0.000      0.00             0
          1000 CF/TON  $/1000 CF   BTU/1000 CF   1000 CF/TON  $/1000 CF   BTU/1000 CF
  GAS:          0.00      0.00             0            0.00      0.00             0
             TON/TON     $/TON       BTU/TON         TON/TON     $/TON       BTU/TON
  SOLID:        0.00      0.00             0            0.00      0.00             0
  SOLID:        0.00      0.00             0            0.00      0.00             0

  MAKEUP WATER:   GAL/TON:  878      $/1000 GAL:  1.00     OR ANNUAL TOTAL:     0
  CHEMICALS:
     CHEMICAL     UNITS/1000 GAL MAKEUP WATER    $/UNIT     OR      ANNUAL TOTAL
      SALT                 5.67                   0.04                   0
      POSO                 0.18                   0.05                   0
                                TOTAL ANNUAL COST OF CHEMICALS:          0
                            IS EVERYTHING CORRECT (Y/N)?
```

```
*** OTHER COSTS ***                                    SCREEN 06
ITEM                          ANNUAL COST        YEAR $
REPAIR PARTS                     45000             84
SEWER                                0              0
INSURANCE                            0              0
PEST/VERMIN CONTROL                  0              0
RESIDUE DISPOSAL                            YEAR $: 83
  (ENTRIES MUST BE MADE FOR EACH OF THE FOLLOWING THREE GROUPS)
     TRANSPORTATION COST OF NON-BURNABLE WASTE ($/TON-MILE):     0.00
     NUMBER OF MILES TO NON-BURNABLE WASTE LANDFILL:               0
     TIPPING FEE AT NON-BURNABLE WASTE LANDFILL ($/TON):         0.00
  OR COST OF LANDFILL DISPOSAL OF NON-BURNABLE WASTE ($/TON):   40.00

     TRANSPORTATION COST OF ASH ($/TON-MILE):                    0.00
     NUMBER OF MILES TO ASH DISPOSAL LANDFILL:                     0
     TIPPING FEE AT ASH DISPOSAL LANDFILL ($/TON):               0.00
  OR COST OF LANDFILL DISPOSAL OF ASH ($/TON):                  10.00

     TRANSPORTATION COST OF ALL WASTE GENERATED ($/TON-MILE):    0.00
     NUMBER OF MILES TO LANDFILL:                                  0
     TIPPING FEE AT LANDFILL ($/TON):                            0.00
  OR COST OF LANDFILL DISPOSAL OF ALL WASTE ($/TON):            40.00
                      IS EVERYTHING CORRECT (Y/N)?
```

*** OTHER COSTS *** SCREEN 07

ITEM	ANNUAL COST	ECONOMIC LIFE YEAR	ECONOMIC LIFE COST	TYPE COST (C,E,L, OR O)	YEAR $
	0	0	0		0
	0	0	0		0
	0	[illegible]	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0
	0	0	0		0

IS EVERYTHING CORRECT (Y/N)?

```
*** OPERATING DATA ***                                              SCREEN 08

TONS OF NON-BURNABLE WASTE/TON OF WASTE:                            0.070
ESTIMATE OF HRI COMBUSTION RATE (TONS/HOUR):                        1.75
HRI TURN-UP CAPABILITY (PERCENT ABOVE NORMAL FIRING RATE):          12.5
TONS OF ASH (BOTTOM OR FLY)/TON OF BURNED WASTE:                    0.30
$/MBTU OUTPUT OF FOSSIL FUEL BOILER AND YEAR $:                      8.70  83
THERMAL EFFICIENCY OF FOSSIL FUEL BOILER (%):                       80.0
HEATING VALUE OF BURNABLE WASTE (BTU/TON):                          10200000
HRI FURNACE TYPE (R=REFRACTORY, W=WATER WALL):                      R
THERMAL EFFICIENCY OF THE HRI (%):                                  48.0
ESTIMATE OF HRI TOTAL ANNUAL DOWNTIME DUE TO FAILURE (%):           18
ESTIMATE OF HRI ANNUAL NUMBER OF FAILURES:                           14
ESTIMATE OF MAXIMUM HRI DOWNTIME (HOURS):                           120
TIME REQUIRED TO COMPLETE A DAYS DELIVERY (HOURS):                   6
STORAGE SPACE AVAILABLE AT HRI (TONS):                               60
HRI OPERATING SCENARIO:
   1=BURN 2 SHIFTS, 5 DAYS   2=BURN CONTINUOUSLY, 5 DAYS            2
   3=BURN 2 SHIFTS, 7 DAYS   4=BURN CONTINUOUSLY, 7 DAYS
   5=BURN CONTINUOUSLY, 4 DAYS, FOLLOWING DAY 1 RECEIPT
HRI PLANNED ANNUAL OPERATING WEEKS:                                 52

                    IS EVERYTHING CORRECT (Y/N)?
```

HRI COST AND PERFORMANCE REPORT

INFLATED PER TON COST OF DISPOSING WASTE OF THE TYPE GENERATED AT THE SITE TO THE LANDFILL:	$52.82
INFLATED PER MBTU COST OF THE FOSSIL FUEL BOILER TO WHICH THE HRI IS BEING COMPARED:	$11.49
TONS OF TRASH BURNED ANNUALLY BY THE HRI:	9,518.
MBTUS PRODUCED ANNUALLY BY THE HRI (CONSIDERING NO DOWNTIME):	6.03E+04
VIRGIN PETROLEUM FUEL OFFSET ANNUALLY BY THE HRI IN BARRELS-OF-OIL EQUIVALENT:	7,966.
LANDFILL SPACE CONSERVED ANNUALLY BY THE HRI IN TONS:	6,663.
COST OF USING A BOILER TO PRODUCE THE ANNUAL NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE:	$1,312,630.
INFLATED TOTAL CAPITAL COST OF THE HRI (INCLUDES EQUIPMENT, SUPPORT FACILITIES, AND CONSTRUCTION AND SETUP):	$3,447,470.
UNIFORM ANNUAL COST OF THE HRI (THE COST OF CAPITAL, MODIFICATIONS. LABOR, CONSUMABLES, RESIDUE DISPOSAL, DOWNTIME, AND OTHER COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI):	$1,293,550.
ANNUAL NO-DOWNTIME COST OF THE HRI (THE TOTAL OF NO-DOWNTIME COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI):	$1,291,820.
DISCOUNTED LIFE CYCLE COST OF USING A BOILER TO PRODUCE THE LIFE CYCLE NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE (COSTS DISCOUNTED TO THE POINT OF INITIAL FUNDING):	$14,105,500.
DISCOUNTED LIFE CYCLE COST OF THE HRI:	$10,365,300.
DISCOUNTED LIFE CYCLE COST OF AUXILIARY FUELS USED BY THE HRI:	$443,336.
DISCOUNTED LIFE CYCLE COST OF NONCOMBUSTIBLE WASTE, ASH, AND SCHEDULED DOWNTIME WASTE DISPOSAL:	$871,954.
DISCOUNTED LIFE CYCLE COST OF HRI DOWNTIME:	$28,713.
DISCOUNTED LIFE CYCLE COST OF THE HRI PER TON OF WASTE FIRED:	$54.45
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER TON OF WASTE FIRED:	$37.51
DISCOUNTED LIFE CYCLE COST OF THE HRI PER MBTU PRODUCED:	$9.96
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER MBTU PRODUCED:	$6.86
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI:	$7,139,690.
HRI SAVINGS-TO-INVESTMENT RATIO:	+2.10
PAYBACK PERIOD IN YEARS (INCLUDES PROJECT LEAD TIME):	9.9

NAS JACKSONVILLE

DAILY OPERATIONL LOGS

PREVENTIVE MAINTENANCE FORMS

SHO NASJAX 11300/11 (10/83)

NAS JACKSONVILLE, FLORIDA
HEAT RECOVERY INCINERATOR
PUBLIC WORKS UTILITIES

DATE:

	INC. & BOILER #1						INC. & BOILER #2						INC. & BOILER #3					
	TEMP BURNER		AIR FLOW		STEAM FLOW	BOILER FEED H_2O	TEMP BURNER		AIR FLOW		STEAM FLOW	BOILER FEED H_2O	TEMP BURNER		AIR FLOW		STEAM FLOW	BOILER FEED H_2O
	PRI	SEC	PRI	SEC			PRI	SEC	PRI	SEC			PRI	SEC	PRI	SEC		
0000																		
0100																		
0200																		
0300																		
0400																		
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1600																		
1700																		
1800																		
1900																		
2000																		
2100																		
2200																		
2300																		

	SIGNATURE
0000 WATCH REMARKS:	
0800 WATCH REMARKS:	
1600 WATCH REMARKS:	

#2 FUEL OIL METER		WASTE OIL METER	#2 FUEL OIL METER		WASTE OIL METER	#2 FUEL OIL METER		WASTE OIL METER
PREVIOUS			PREVIOUS			PREVIOUS		
TODAY			TODAY			TODAY		
TOTAL			TOTAL			TOTAL		
	IN	OUT		IN	OUT		IN	OUT

INCINERATOR AND BOILER HOURS			
EQUIP. NO.	HOUR - TODAY	HRS SINCE CLEANING	TOTAL HRS
#1 INC			
#1 BOILER			
#2 INC			
#2 BOILER			
#3 INC			
#3 BOILER			

ELECT USAGE SW 1	
METER READING X 120 =	
PREVIOUS	
TODAY	
COUNT	X 120
TOTAL	

FUEL OIL TANK SOUNDINGS				
	#2 OIL		WASTE OIL	
	INC	GAL	INC	GAL
PREVIOUS				
TODAY				
TOTAL				

TOTAL WASTE REC POUNDS		lbs.
ASH OUT		lbs.
INSIDE METAL		lbs.
UNDERSIZE & CANS		lbs.
TOTAL MAKE UP H_2O		gal.
TOTAL FUEL USED		gal.
TOTAL STEAM GENERATED		lbs.
HOURS PROCESSED		hrs.
ASH CONVEYOR WATER		
PREV.		
TODAY		
TOTAL		gal.

LOGS REVIEWED BY:

SIGNATURE: ______________

EQUIPMENT METER READINGS			
	0000	2400	
1			FLAIL MILL CONV.
2			SHREDDER CONV.
3			STORAGE BIN CONV.
4			ASH CONVERTER
5			INC BLOWER #1
6			INC BLOWER #2
7			INC BLOWER #3
8			I.D. #1
9			I.D. #2
10			I.D. #3

PREVENTIVE MAINTENANCE PROGRAM

Name of Facility: JACKSONVILLE NAVAL AIR STATION

JAN. 1 2 3 4	FEB. 1 2 3 4	MAR. 1 2 3 4	APR. 1 2 3 4	MAY 1 2 3 4	JUNE 1 2 3 4	JULY 1 2 3 4	AUG. 1 2 3 4	SEPT. 1 2 3 4	OCT. 1 2 3 4	NOV. 1 2 3 4	DEC. 1 2 3 4

Equipment Location ______ Equipment Record Name ______

EQUIPMENT DESCRIPTION	MECHANICAL DATA	ELECTRICAL DATA
Name	Model	Model
Serial No.	Serial No.	Serial No.
Vendor	Type	Frame
Vendor Address	Size/Capacity	Type
Vendor Rep. Phone	RPM	Code Letter
Initial Cost Date	Spec.	H.P.
		Volts/Amps
		RPM
		Hertz
		Phase
		Rating
		Nema Design
		Insulation Class
		Service Factor

Date of Manuf.:	Date Put Into Service:	Date Replaced:	Length of Service:

MAINTENANCE DATA

Lubricant: Type: Frequency:

Seal: Type: Frequency:

Coating: Type:

Spare Parts:

Special Tool Requirements:

Remarks: ______ (Over)

WORK TO BE DONE	FREQUENCY	TIME

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED

HRI EQUIPMENT STATUS LOG

1. INSTALLATION	2. BEGINNING DATE YEAR MONTH DAY	3. PAGE ___ OF PAGES ___

4. DATE	5. TIME	6. CODE	7. MHRS	8. EXPLANATIONS

9. FOR ANALYST ONLY	10. SUPERVISOR

II. CODES FOR EQUIPMENT STATUS LOG

The following codes will be used in conjunction with the entry made in the remarks column. An "R" next to any code indicates performance of routine (preventive) maintenance during this period. Start and completion times of routine maintenance must be indicated in appropriate column of equipment log.

CODE	DEFINITION
1	UP-Operating. Equipment is energized and is being operated at full or reduced capability. Certain routine maintenance action should also be reported in this or other UP code.
2	UP-Secured. Equipment is idle; not energized but capable of being operated. Includes time (shutdown) due to reasons other than routine maintenance or failure. Examples would be lack of solid waste or fuels, holidays, and weekends.
3	DOWN-Corrective Maintenance. Equipment is idle and not fully operable using normal operating procedures because corrective maintenance is being performed. That is, some equipment is undergoing repair, part replacement, alignment, or adjustment in order to correct a failed or out of tolerance condition.
4	DOWN-Awaiting Spares. Equipment is not fully operable using normal operating procedures because spare parts are needed which are not available within the facility. The equipment cannot be restored to an operable status until parts are procured.
5	DOWN-Awaiting Outside Assistance. The equipment is not capable of operating at full or reduced capability on demand and requires assistance from other than NRI personnel to restore to operable status.
6	DOWN-Administrative Delay. The equipment is not capable of operating at full or reduced capability on demand. This includes time for lunch, dinner, holidays, shift changes, etc.
7	DOWN-Preventive Maintenance. Planned or routine maintenance is being performed which renders the equipment inoperable until completion.

III. CODES FOR SYSTEMS AND COMPONENTS

The following codes will be used to show system status.

CODE	DEFINITION
A	Ash handling subsystem - includes motor and conveyor.
B	Boiler subsystem - includes, boiler, water and steam lines, makeup water equipment, and blowdown components.
N	NRI - includes all equipment.
I	Incinerator subsystem - includes incinerator, controls, feed hoppers, stokers, and burners.
P	Processing subsystem - includes flail mill, shredder, magnetic separator, trommel, and associated feed/discharge conveyors.
R	Receiving subsystem - includes tipping floor and front-end loader.
S	Storage subsystem - includes storage bin, screw augers, and feed conveyors.
T	Heat transfer subsystem - includes B and I.

The following two pages provide an example of completed equipment status logs representing an entire week. This sample scenario begins with the start of a work week (Monday morning).

END

FILMED

12-84

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